HUMAN INFORMATION PROCESSING FOR DECISIONS TO INVESTIGATE COST VARIANCES

By

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Two major functions of management are those of planning and control. Broadly defined, control is the management process which assures that selected alternatives are implemented and executed in accordance with plans. Important aspects of the control process concern analysis and investigation of standard cost variances provided within accounting reports. A substantial portion of the accounting variance investigation literature has employed the normative model approach-- researchers have created variance investigation models which a manager should use. Rarely has attention been given to how the manager would interprete and integrate information required by the various normative models.

The principal focus of this dissertation was on the effects of specific situational variables upon a manager's information processing for purposes of making variance investigation decisions. The specific objectives were 1) to develop a conceptual framework which will predict effects of specific situational variables on a manager's relative efficiency in information processing and in variance investigation decision making, and 2) to empirically test some implications of this conceptual framework.

Variables that can affect the manager's variance investigation decision process include 1) structure of the decision situation, 2) contents of the available information set, 3) manager's information processing efficiency, and 4) manager's learning efficiency. The structure of the decision situation depends upon number possible states of control, relative frequencies of the states, various statistical relationships among the states, and various relationships between the decision/state outcomes. The contents of the available information set include information known by the manager prior to his decision. The manager's information processing efficiency relates to the particular strategies employed in combining and weighting various items of information. The manager's learning efficiency refers to the manager's ability to learn from his experiences with the controlled process. Both information processing and learning efficiency are the results of the manager's particular decision strategies. These decision strategies were expected to adapt a general form, referred to as anchoring and adjustment. A natural starting point is used as a first approximation for the investigation decision rule and is then adjusted as the manager learns from his experiences.

Two experimental methods were used to derive and test implications of the conceptual framework. Simulation techniques were used to operationalize hypotheses and a laboratory experiment was used to test these hypotheses.

The experimental environment was that of an assembly department within a simulated manufacturing company. The assembly department assembled a single product and performance of this department was determined completely by the assembly workers' labor efficiency. Student

subjects, who assumed the role of assembly department operational manager, made labor efficiency variance investigation decisions based upon a series of independent standard cost variance reports. The manipulated independent variables included contents of the available information set, distributional properties of the states of control, and cost effects of the investigation decision errors. Parameters of the psychological theory of signal detection permitted measurement of sensitivity and criteria of a subject's decision model. The subject's investigation decision costs compared to normative investigation decision costs derived under similar situations were employed as a relative measure of decision efficiency.

Overall, the implications of the conceptual framework were supported by the obtained results. To explain the few major deviations from expectations, an ex post hypothesis was introduced. This hypothesis posits that the standard introduces a subjective adjustment bias. Depending upon the direction of adjustment the standard subjectively inhibits complete adjustment either to optimal decision values close to the standard or to optimal decision values distant from the standard.

CHAPTER I

INTRODUCTION AND OBJECTIVES

Business organizations generate internal accounting reports for use by managers for purposes of evaluation and decision making.[1] One important evaluation process and decision task of management is that of standard cost variance analysis and investigation. Based in part upon standard cost variance reports generated by the internal accounting system, managers estimate the likelihoods that various production processes remain under control and decide whether to investigate particular variances. The present study concerns the effects of selected variables on standard cost variance investigation decision making by operational control managers. This chapter discusses general aspects of the standard cost variance investigation decision process and the variables which may affect the process and presents the research objectives of the study.

Variance Investigation Decision Processes

An important factor in the evaluation and use of standard cost variance reports is the manager's perception of the validity of the

[1]The American Accounting Association 1966 Statement of Basic Accounting Theory states that "the objective of accounting for internal use is to provide information to persons within an organization that enables them to make informed judgements and effective decisions which further the organization's goals" (p. 38).

information provided. In particular, the manager's perception of the standard setting process will have considerable influence upon his variance investigation decision process. If the manager believes that the standards are unrealistic (i.e., that the standards have been placed too far from the in-control distribution) he may rescale either the standards or the variances to correspond with his own perception of the in-control distribution.[2]

If it is assumed that a manager accepts the standard setting process as realistic and does not rescale the standards or variances, his variance investigation decisions may be viewed as the culmination of a two-stage process. The first stage concerns the detection of the particular distribution (e.g., in-control or out-of-control) that generated the variance. The manager's performance of this task is a function of the sensitivity of his decision process (model). This sensitivity is affected by the structure of the particular situation and by the manager's knowledge of this structure. The extent of the manager's knowledge of the situation, in turn, is affected by the available information (both contained within the variance report and provided from other sources), and by the manager's ability to learn from his experiences with the processes being controlled. In situations where the controlled process distributions have some area of overlap the results of a manager's detection process are probabilistic (i.e., prior to completing an investigation the existence of any given state is uncertain). Furthermore, the greater the area of overlap, the more difficult the discrimination task becomes.

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[2]Within this context, an in-control distribution concerns statistical congruence of production output and planned output in terms of controllable resource utilization.

The second stage concerns the manager's investigation decision criteria. Having arrived at a conclusion (albeit probabilistic) about the distribution that generated the variance, the manager must integrate and process various objective function parameters in order to arrive at his variance investigation decision (these parameters can belong to either the manager's objective function, the organization's objective function, or both if the same). The potential investigation criteria can be divided into two major categories: structural criteria and behavioral criteria. The first category can be divided further into structural cost criteria and structural probability criteria. The structural cost criteria include such variables as the additional cost of operating an out-of-control process (given that the process can be returned to the original in-control state), and the costs of variance investigation and correction (which can differ depending upon the actual state that generated the variance). The structural probability criteria include such variables as the probability that the source of the variance is controllable (i.e., that it can be returned to the original in-control state through managerial action), the probability that the process will return to the in-control state without managerial action, and the prior probabilities of each state distribution. The behavioral criteria include such variables as the manager's perception of the effect of the investigation upon his performance evaluation and reward structure, and the manager's perception of the effect of the decision upon employee performances and attitudes.

Although the variance investigation decision process has been described as two stages, the manager may not actually utilize such a sequential stage process. The manager's actual decision process is

labeled a heuristic. Within this context, heuristic refers to the learned set of rules or principles that are utilized by the individual in making the particular decisions required of him. The manager's specific heuristic can be affected substantially by his individual characteristics (e.g., intelligence, cognitive complexity and style, decision process sensitivity, motivations, etc.). However, a general heuristic, labeled anchoring and adjustment (Tversky and Kahneman, 1974), is expected to describe the general form of the manager's variance investigation decision process.[3]

The above examination of the manager's variance investigation decision process indicates that the variables which can affect both the process and the results of the process include 1) the structure of the decision situation, 2) the contents of the available information set, 3) the manager's information processing efficiency, and 4) the manager's learning efficiency (from his experiences with the controlled process). The manager's knowledge concerning the structure of the decision situation may be limited by the contents of the available information set and by his information processing and learning efficiencies. The accountant, to a large extent, has control over the contents of the available information set.

The Research Objectives

Many problems in accounting reduce to one of choosing among alternative information sets that could be provided to a decision maker (American Accounting Association, 1972). Two basic approaches to

[3]The anchoring and adjustment heuristic is described in greater detail within Chapter II.

deciding on the information set to be presented within the cost variance report have been advocated. First, the accountant can determine those models which managers use in making variance investigation decisions and provide an information set which would permit the implementation of these models. Problems with this individual model approach are 1) the possibility exists that different individual models use a wide range of different information sets (which are not costless), and 2) the individual models may not be optimal (i.e., they could be inefficient with respect to other decision models). The individual model approach centers on the psychological question of what the manager is doing (or would do) with the available (or additional) information. Second, the accountant could create a normative model of the variance investigation decision and provide the information required by that model. Problems with the normative model approach are 1) the information provided may not optimize the individual's investigation decisions (which may continue to be made using the individual's model), and 2) the costs associated with operationalization of the normative model may exceed the benefits (cost savings as a result of more optimal investigation decisions and greater congruence of manager goals with overall organization goals) offered by the model. The normative model approach centers on the analytical question of what the manager should be doing (or should do) with the available (or additional) information.

A substantial portion of the accounting variance investigation literature has focused upon the second approach-- the normative model approach.[4] However, rarely has attention been given to how the manager

[4]This literature is reviewed within Chapter II.

would interprete and integrate the information sets of the various normative (optimal) variance investigation models. In many instances the implicit assumption has been that the manager would process the information with the same efficiency as the normative model.

The principal focus of this research is the effects of specific situational variables on a manager's variance investigation decisions (relative to the investigation decisions of an optimal model) and on a manager's processing of available information (relative to the information processing of an optimal model). Specific objectives are:

1) To develop a conceptual framework which will predict the effects of situational variables on a manager's relative information processing efficiency and to empirically test the implications of this conceptual framework.
2) To develop a conceptual framework which will predict the effects of situational variables on a manager's relative variance investigation decision efficiency and to empirically test the implications of this conceptual framework.

Dissertation Organization

Chapter II presents certain general concepts from accounting and psychology. These concepts are necessary for the development of the specific environment studied in this research, and for the development of a conceptual information processing and decision making framework within this environment. The accounting concepts are concerned with the nature of managerial decisions, managerial task planning and control, and standard cost variance investigation. The psychological concepts are concerned with the theory of signal detection and with cognitive

aspects of human information processing such as the general heuristic of anchoring and adjustment.

Chapter III synthesizes the general concepts of the previous chapter and develops a conceptual framework of standard cost variance investigation employing the methodology of the psychological concepts. This conceptual framework was operationalized using simulation techniques, and experimental hypotheses were derived from the simulations.

The details of a laboratory experiment designed to test the hypotheses derived from the conceptual variance investigation framework are presented in Chapter IV. The experiment employed a between-subjects design and was manipulated factorially using specific variance investigation situation variables. Modified parameters from the psychological theory of signal detection were employed to measure subject's information processing efficiency and decision model sensitivity.

The results obtained from the laboratory experiment are presented in Chapter V. The model comparison procedure of non-orthogonal analysis of variance was the primary method of analysis employed. Chapter VI discusses the results, develops a modification (ex post) of the original conceptual framework, and discusses some implications for accounting and for future accounting research.

CHAPTER II

AREA OF INVESTIGATION

Managerial Accounting Concepts

This study relies on the synthesis of certain psychological concepts with certain accounting concepts. This section discusses the accounting concepts: the nature of managerial decisions, managerial task planning and control, and standard cost variance investigation.

Managerial Decisions

Since the information set (accounting report) exists to support the manager's tasks, a conceptual framework of managerial decisions would facilitate the accountant's information set selection. A conceptual framework of managerial decisions should differentiate managerial decisions along dimensions that allow insights into the informational needs of those decisions.

Anthony (1965) provides one such dimension along which he identifies the purposes or orientation of managerial activities: strategic planning, management control, and operational control. Another dimension is provided by Simon (1966) who distinguishes between programmed and nonprogrammed decisions. The underlying dimension is concerned with the manner in which managers deal with their problems. The criteria for classifying a decision consist of the extent of structure associated with the problem solving phases of the decision.

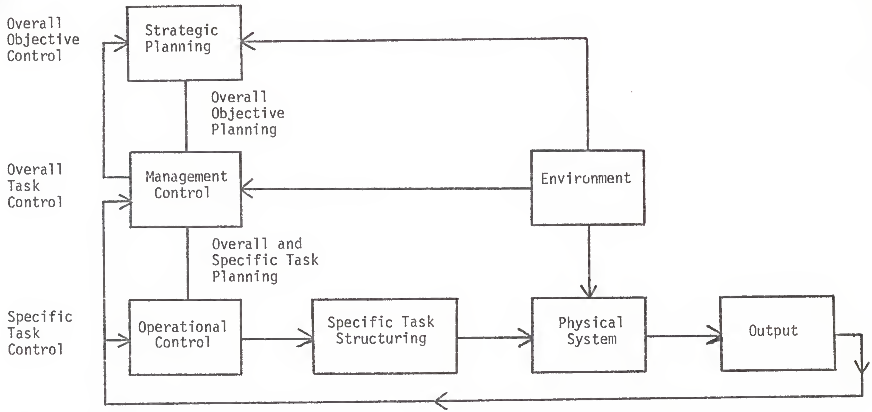
A conceptual framework of managerial decisions that synthesizes these dimensions is presented by Gorry and Morton (1971). Simon's dimension is modified by replacing the terms "programmed" and "non-programmed" with the terms "structured" and "unstructured" and adding a third category labeled semi-structured. Gorry and Morton's conceptual framework is used in this research as a model that will permit the identification of a standard cost system within the overall managerial decision framework.

Management Task Planning and Control

Standard cost systems present information sets to managers to support various decisions concerning task planning and control. Demski (1967) provides an excellent conceptual discussion of the management task planning and control process, and his approach (with some modification) is adopted in this research.

Figure 1 presents a model of the management task planning and control process. Environmental information, largely external to the standard cost system, facilitates the planning of overall goals and policies within the constraints imposed by the environment. Overall objective control feedback 1) provides evidence for the continued validity of overall assumptions made in forming the organization objectives, and 2) facilitates strategic planning evaluation of organization performance.

Both the environmental variables and the overall task control feedback of the management control activity 1) provide evidence for the continued validity of the overall task assumptions made in forming



Source: Modified from Demski, 1967.

FIGURE 1

MANAGEMENT TASK PLANNING AND CONTROL PROCESS

the task plans, and 2) facilitate management control evaluation of operational control performance.

The operational control manager uses the specific task control feedback to 1) decide whether the physical system performance is in agreement with the specific task plan, and 2) to decide whether the task can be restructured to bring performance back into agreement with the plan (if performance and the plan differ). A task that can not be restructured could have significance for the overall task control feedback to the management control activity and possibly may lead to modification of the original task plans. Such modification could in turn have significance for the overall objective control feedback to the strategic planning activity, and a modification of the original overall objectives may follow.

Standard Cost Variance Investigation

Within the operational control activity the specific task plan provides standards of performance in terms of expected component costs and usages, and the desired physical outputs. The operational control manager structures the tasks within the physical system and periodically receives a standard cost variance report describing the system output in terms of the task plan and the actual results. Upon receiving a variance report the manager must decide the nature of the given variances.

Dopuch et al. (1967) present a classification of standard cost variances that is based on the expected source of the variances. A variance resulting from a random fluctuation of the physical system, labeled a Type 1 variance, requires no operational control response if

not statistically significant. Whether a variance resulting from a change in the physical system, labeled a Type 2 variance, requires an operational control response depends on whether the underlying cause of the change is a temporary rather than a permanent phenomena. A temporary or controllable variance, labeled a Type 2a variance, is one that operational control can correct in the future (i.e., the physical system can be returned to the previous in-control condition). A permanent or noncontrollable variance, labeled a Type 2b variance, is one that operational control can not correct in the future.

If the manager decides that the variance is of Type 1 no action is required. If, however, the manager decides that the variance is of Type 2 he must then decide if the variance should be investigated for its underlying causes. Should the variance be of Type 2b it would have little operational control significance; should the variance be of Type 2a the cause of the variance could be eliminated by restructuring the physical system. The present study confines itself to the assumption that all variances which result from a change in the physical system are controllable by the operational control activity. In other words, it assumes that the standard cost variances have no significant affect on either the strategic planning or the management control activities.

The information set contained in a standard cost variance report can be viewed as relating to one of two categories of information: distributional properties of system states and investigation decision criteria. The distributional properties category can include such variables as 1) the mean and standard deviation of the output when the system is known to be in-control, 2) the mean and standard deviation of

the output when the system is known to be out-of-control, 3) the actual output for the period, and 4) the deviation between the standard output and the actual output for the period (the standard output variance). The investigation decision criteria category can include such variables as 1) the prior probabilities of the system's states, and 2) the costs and benefits associated with each possible investigation decision in combination with each possible system state.

Information relating to investigation decision criteria that is not typically presented within the variance report includes 1) the probability that the cause of the variance is controllable (assumed by this research to equal one), 2) the probability that the system will return to the in-control state without managerial action (assumed by this research to equal zero), 3) the perceived effect of the investigation decision on manager performance evaluation, and 4) the perceived effect of the investigation on employee performances and attitudes.

The variance investigation literature is concerned mainly with the investigation significance of Type 1 and Type 2a variances. A general approach described within the literature is that of the Shewhart $\overline{X}$ chart procedure (Probst, 1971; Koehler, 1968; Luh, 1968; Jeurs, 1967; Zannetos, 1964). This approach, based upon classical statistics, involves sampling the system to construct an in-control mean and standard deviation. Arbitrary control limits (generally plus or minus three standard deviations) are used as the criteria for making a variance investigation decision. Only one of the above studies considered the effects of the information provided on the manager's investigation decision. Probst (1971), in an industrial field study, found foremen unwilling to accept the procedure as their investigation decision rule

when the procedure was constructed objectively (the foremen indicated the reason for not accepting the procedure was that they felt it ignored their experience). However, Probst did not analyze his results in terms of the performance efficiency of the foremen.

Other research has noted what are considered to be significant drawbacks to the Shewhart $\overline{X}$ chart procedure: the failure to consider the costs and benefits associated with the various investigation decision outcomes and the failure to consider information from prior periods. Bierman et al. (1961) proposed the incorporation of investigation decision costs and benefits within a classical statistics framework. Thus managers may use statistical information to calculate the probability that the variance reflects the in-control state, and combine this probability with the investigation decision costs and benefits. Most of this information is assumed to be provided by the accountant and accurately processed by the manager.

Kaplan (1975) and Jacobs (1978) have considered another deficiency of the classical statistics approach-- the failure to use prior period information. They analyze the use of the cummulative sum procedure, whereby the cumulative sum of the variance is charted for each period. Theoretically, under a stable state these sums should follow a random walk, and any drift would indicate the system is out-of-control. Evaluation of such a drift would be accomplished on the basis of information provided by the accountant or derived from the manager's experience. The economic cumulative sum procedure incorporates the effects of estimated investigation decision costs within the drift evaluation.

Several studies in the variance investigation literature use decision theory to construct a variance investigation model (Kaplan,

1969; Dyckman, 1969; Kaplan, 1975; Dittman and Prakash, 1978). If all the parameters required by these models were available these models could replace the manager as the variance investigation decision maker. However, to the extent that not all the parameters are operationalizable (given some cost constraint), the manager must continue to make the variance investigation decisions using the information provided by the accountant and by his own experiences.

A conclusion that can be drawn from the variance investigation literature is that the additional information proposed for the use of managers is becoming both diverse and complex. Furthermore, there is a paucity of research relating to the manager's ability and efficiency to interpret and integrate this additional information. Demski (1970, 1971) was one of the first to note the problem associated with the decision-implementation interface (i.e., the effect of the control system information on individual behavior and performance). Some analytic research on this problem has followed. Using simulation techniques, Magee (1976) compared average total cost for seven decision rules under various operational conditions. Although the simpler decision models (rules) tended to have larger average costs than the more sophisticated decision models, the difference in average cost was relatively small. Indeed, if model implementation and information costs are considered the simpler models may be more efficient than the sophisticated models. Magee also noted that because of the use of different manager performance measures (average operating costs, average number of months below standard, etc.) simpler decision models may result in rational choices (i.e., choices that maximize the manager's expected utility). Closely related to Magee's research is an empirical

study by Magee and Dickhaut (1977). Using human subjects, Magee and Dickhaut found support for the proposition that different manager performance (payoff) measures will affect the specific decision rules (heuristics) employed by the decision maker (as a result of the decision maker attempting to maximize his subjective utility).

Psychological Concepts

This section discusses the psychological concepts employed in developing a conceptual framework of manager standard cost variance investigation decisions. These concepts include the psychophysical theory of signal detection and the human information processing concepts of decision heuristics.

Psychophysics

Psychophysics studies the relationships between physical and psychological scales of measurement. Modern psychophysics adopts the view that subjects can make meaningful evaluations of the magnitudes of their sensory experiences, and therefore sensory magnitudes, as well as physical magnitudes, can be quantified. One approach of modern psychophysics is based upon the theory of signal detection (TSD). TSD permits the separation of the decision maker's ability to discriminate between classes of stimuli (sensitivity) from his motivational response biases (decision criteria). Two comprehensive theoretical descriptions of TSD are presented by Green and Swets (1974) and Egan (1975); general surveys of the TSD theory are presented by Coombs et al. (1970), Watson (1973), and Pastore and Scheirer (1974).

The basic TSD experiment utilizes the single-interval procedure. This procedure consists of a series of trials, each trial consisting of an observation interval and a response interval. The possible stimulus events during the observation interval are 1) the observation contains a meaningful signal added to a background of noise (sn trial), and 2) the observation contains only a background of noise (n trial). It is assumed that each trial is independent of all other trials and that the prior probabilities of n and sn are given and remain constant. The background noise fluctuates at random from trial to trial; the stimulus (usually a fixed level) is added to the noise. Therefore, the observation fluctuates randomly from trial to trial. The task of the subject is to detect whether the observation was generated by the signal plus noise (sn) or by the noise alone (n) distribution. That is, in the response interval the subject will respond with either "Yes, the signal was present" (Y response), or "No, the signal was not present" (N response).

On any trial there exist four possible outcomes of the subject's decision in conjunction with the actual distribution: 1) sn was presented and the subject said "Yes" (a hit), 2) sn was presented and the subject said "No" (a miss), 3) n was presented and the subject said "Yes" (a false alarm), and 4) n was presented and the subject said "No" (a correct rejection). A conditional probability matrix for a series of these events is given by the following (Green and Swets, 1974):

		RESPONSE	
		Yes	No
STIMULUS	sn	$P(Y\|sn)$	$P(N\|sn)$
	n	$P(Y\|n)$	$P(N\|n)$

Since the cells of this matrix are both exhaustive and mutually exclusive, the row-wise conditional probabilities must sum to one (this does not necessarily hold for the sum of the column-wise conditional probabilities). All parameters of the TSD model are derived from this conditional probability matrix (see Appendix A for a more detailed discussion of the conditional probability matrix including its relationship with Bayes' theorem).

In the single-interval task the subject analyzes the evidence and classifies the stimulus into one of two categories according to his criteria. The criteria are determined by his objective function. The objective funcition of interest within this research is the maximization of expected value. Assume that the subject has some value (utility) for each of the four event outcomes. A payoff matrix of these values related to the four outcomes is given by the following (Egan, 1975):

		DECISION	
		Yes	No
STIMULUS	sn	$V_{sn,Y}$	$V_{sn,N}$
	n	$V_{n,Y}$	$V_{n,N}$

The decision rule for maximizing the expected value (see Appendix A for a derivation of this decision rule) is:

$$\frac{P(x|sn)}{P(x|n)} > \frac{P(n)}{P(sn)} \cdot \frac{V_{n,N} - V_{n,Y}}{V_{sn,Y} - V_{sn,N}}$$

At the point at which the above expression is an equality the subject should be indifferent between saying "Yes" or saying "No." This point can be considered the critical value of the likelihood ratio of the observations, $L(x_0)$. The decision rule for saying "Yes" is expressed by the relation $L(x) > L(x_0)$.

The critical value $L(x_0)$ for this decision rule has two possible values: a theoretical value which is a measure of the criteria of an optimal (or ideal) subject and a subjective value which is a measure of the criteria of an actual subject.

One set of TSD models assumes that both conditional probability distributions are Gaussian; i.e., $\phi(x|n)$ and $\phi(x|sn)$ are normally distributed. With the additional assumption of equal variance for both distributions, the parameters which measure individual discrimination sensitivity and individual decision criteria are labeled d' and β, respectively. The discriminability measure, d', has the following theoretical definition:

$$d' = \frac{\mu_{sn} - \mu_n}{\sigma} = z_n - z_{sn}$$

where, μ_{sn}= the mean of the signal plus noise distribution;

μ_n = the mean of the noise alone distribution;

σ = the standard deviation of both distributions;

z_n = the value of the normal distribution function associated with the noise alone distribution and any decision axis cutoff value common to both distributions; and

z_{sn}= the value of the normal distribution function associated with the signal plus noise distribution and any decision axis cutoff value common to both distributions.

The d' measure theoretically is independent of the decision criteria measure.

The decision criteria measure, β, has the following theoretical definition:

$$\beta = \phi(z_{sn}) \;/\; \phi(z_n)$$

where $\phi($ $)$ denotes the normal density function for the point in parentheses and the z parameters are the same as defined for the d' measure.

Although the assumption of equal variance normal distributions is employed within this research, such an assumption is not necessary to employ TSD. Egan (1975) demonstrates the use of TSD with exponential distributions, chi-square distributions, Bernoulli distributions, and Poisson distributions. Grier (1971) develops nonparametric measures of discriminability and decision criteria.

Traditionally, psychophysics has employed TSD to study perceptual processes: i.e., sensory processes such as audition and vision. Over the last decade, however, TSD has been applied to conceptual processes. These extensions to conceptual processes have included numerical processing (Lieblich and Lieblich, 1969; Hammerton, 1970; Weissman et al., 1975), medical diagnosis (Lusted, 1969; Lusted, 1971; Swets, 1972), conceptual judgement (Ulehla et al., 1967a; Ulehla et al., 1967b), and memory (Bernbach, 1967; Banks, 1970).

Human Information Processing

Human information processing (HIP), a subset of cognitive psychology, studies human judgement and decision making with particular emphasis on the processing of information that determines these activities. An area within HIP is the construction of models of human decision making. The work within this area is typically classified into schools of research which employ different paradigms, the two major paradigms being the Bayesian and regression approaches (Slovic and Lichtenstein, 1971). The TSD model is related to the Bayesian approach.

The Bayesian approach is a normative model specifying how a decision should be made given certain internally consistent relationships among probabilistic beliefs. The basic beliefs of this approach are that decisions should be based on subjective probabilities and that these probabilities should be revised upon the receipt of additional information in accordance with Bayes's theorem.

The major findings of Bayesian research are labeled conservatism. The subjects, after receiving additional information, revise their posterior probabilities in the same direction as the optimal model but the revision is insufficient. Much of the research has focused on an explanation of the cause of conservatism, the major explanations being misperception (Peterson et al., 1968), misaggregation (DuCharme and Peterson, 1968), and response bias (DuCharme, 1970).

Another area within HIP is the study of subjective information processing principles and decision rules, labeled heuristics. A heuristic, within this context, refers to a learned set of rules or principles which are utilized by individuals in making the particular decisions required of them. Research in this area has been concerned with identifying systematic biases (relative to some definition of optimal) of subjective heuristics within certain types of decision tasks. Those information processing and decision rule biases identified thus far have been labeled as an anchoring and adjustment heuristic (Tversky and Kahneman, 1973), a representative heuristic (Kahneman and Tversky, 1972; Swieringa et al., 1976), an availability heuristic (Tversky and Kahneman, 1973), and the law of small numbers (Tversky and Kahneman, 1971).

This study will make particular use of the anchoring and adjustment heuristic. In many situations, individuals first make decisions by starting with an initial anchor (decision point) and then adjust this initial anchor as they learn from their experiences. The initial anchor can be suggested by the structure of the decision situation, or can be the result of a partial computation or estimate. Empirical tests involving the anchoring and adjustment heuristic indicate individuals do not sufficiently adjust their initial decision point. That is, their adjustment is less than that which would allow optimal processing of the available information (Slovic and Lichtenstein, 1971; Slovic, 1972; Alpert and Raiffa, 1968; Tversky and Kahneman, 1974).

CHAPTER III

RESEARCH METHODOLOGY AND DESIGN

General Conceptual Development

A general problem confronting decision makers is that the individual must decide subjectively which state of nature is most probable based upon some incomplete set of information. When an individual deals repetitively with a similar situation his long-run decision efficiency or "decision correctness" can be affected by 1) the structure of the particular decision situation, 2) the contents of the set of available information, 3) his efficiency in processing the available information, and 4) his ability to expand the available information through experience with, and observations of, the various states of nature. Each of these four elements is discussed below with specific reference to the objectives of this research.

Decision Situation Structure

The structure of the particular decision situation primarily depends upon several key variables. These variables include the number of possible states of nature, the relative frequencies of the states, the various statistical relationships among the states, and the relationships between the various decision outcomes (the costs incurred given a specific decision and the existence of a specific state). Depending on

the specific values which these variables may assume, the structure of the particular decision situation can affect both the difficulty and the importance of the individual's discrimination among the states. In general, as the number of possible states increases and as the area of distributional overlap of these states increases the discrimination task becomes more difficult. Furthermore, the discrimination task becomes more important (in terms of incurred costs) as the relative frequencies of the states become equal and as the costs associated with the possible decision outcomes which involve decision errors (an incorrect decision given the existence of a specific state) become unequal.

The general situation employed in this research, selected for its relevance to the accounting discipline, is the cost variance investigation decision. In this situation two states of nature are possible: 1) in-control (the underlying physical process described by the standard cost variance report is functioning as planned), and 2) out-of-control (the underlying physical process described by the standard cost variance report is not functioning as planned). In reality, the possible states of nature may be located on a continuum whose end points are the states of in-control and out-of-control. Between these two end points are any number of states that take the general form of partially out-of-control or moving out-of-control. In the present research the possible states of nature are confined to the two end points. The relative frequencies of the two states are controlled as constants with their values being close to equal. The statistical relationships among the two states and the relationships between the various decision outcomes are manipulated as independent variables.

Available Information Set

The contents of the available information set refers to the information known by the individual prior to his decision. Such information can be of two types-- singular or distributional (Tversky and Kahneman, 1977). Singular information consists of information that specifically relates to the current decision. Distributional information consists of information that relates to the relative frequencies and to the statistical relationships among the states of nature.[1] The difficulty of the discrimination task may be affected by the presence or absence of certain items of information. In general, the less information contained in the available set the more difficult the discrimination task, for missing information required by a decision model must be estimated by the individual. Compared to statistically derived estimates, these subjective estimates are likely to have greater uncertainty and inefficiency associated with them.

Within the variance investigation situation, the information contained on each variance report constitutes the singular information. Two types of singular information are employed in this research-- the actual results of the physical process and its variance from a standard, and the marginal costs associated with each of the two possible decisions in combination with each of the two possible states of nature. The presence of both these singular information types is controlled as a constant within this research. The presence or absence of specific

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[1]This definition of distributional information implicitly assumes that the relative frequencies and statistical relationships are stable over the relevant time frame. If these variables were non-stable, revised estimates of their specific values would be required prior to each decision, thus classifying them as singular information. This research assumes that both of these variables are stable across all decisions.

distributional information items (the statistical means, variances, and distributional shapes of the two states) is manipulated as an independent variable. The presence of other distributional information items (the relative frequencies and the allowed standard) is controlled as a constant.

Individual Information Processing Efficiency

The individual's efficiency in processing the available information relates to the particular heuristics or strategies employed in combining and weighting the various items of information. The term efficiency implies a relationship between the individual's process output (his decision) and a normatively correct or optimal decision. The individual's decision and information processing performance can be evaluated by comparing his performance against an optimal model. Optimality refers to the best possible performance under given conditions. Since the optimal decision model relies on an incomplete information set rather than certain knowledge,even its performance can be affected by both the structure of the situation and the contents of the available information set.

The optimal models used in this research are a function of the experimental environment: the single-interval procedure found within the psychological theory of signal detection and the basic decision situation of standard variance investigation. Within this environment the optimal decision rule for minimizing (maximizing) the expected cost (value) of a set of decisions is based upon an extension of Bayes' theorem that takes into account the relative costs (values) of various

possible decision outcomes. The parameters required to fit the optimal model include 1) the relative frequencies of the two states of nature, 2) the mean of each state, 3) the statistical variance of each state, and 4) the costs associated with each of the two possible decisions in combination with each of the two possible states of nature. Since the individual's decisions are to be evaluated by comparisons with the outputs of the optimal model, it would seem reasonable that the information available to the optimal model be the same as the information available to the individual. Consequently, for decision situations in which some of the parameters required by the optimal model are not contained in the available information set the optimal model must make estimates of the missing parameters.

Individual Ability to Expand the Information Set

The individual's ability to expand the available information set over time refers to his ability to learn from his experiences with the states of nature. Such learning can occur through improved estimates of unknown items of distributional information and through modifications of information processing strategies to incorporate state relationships which were unknown or undetected previously.

The general form of the expected individual information processing strategy is described by the heuristic of anchoring and adjustment (Tversky and Kahneman, 1974).[2] A natural starting point, or anchor, is used as the first approximation for the decision. This anchor is then

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[2]A heuristic, within this context, refers to a learned set of rules or principles which are utilized by an individual in making the particular decisions required of him.

adjusted as the individual learns from his experiences with the states of nature.

Within the present study the initial decision points or anchors were expected to fall near the geometric intersection (either actual or estimated, depending upon the available information) of the distributional curves of the two states. Adjustments from these initial decision points by the individual were expected to occur during the training phase of the experiment as the individual gained experience with the states and received feedback as to his performance (relative to an optimal model). The extent of an individual's adjustments (his learning efficiency) is measured using several variables. Each variable measures the relative extent of adjustment (or lack of adjustment) from the original decision anchor toward the optimal value of that variable.

General Research Design

As stated previously, the focus of this research is on human decision making and information processing within a particular decision context-- that of standard cost variance investigation. Much of the variance investigation literature within accounting has focused on how the decision maker should integrate the available information and make the investigation decision (see Kaplan, 1975 for a review of this literature). Very little research has been concerned with how the decision maker does accomplish these processes. The major objective of this research is to study the processes used by the decision maker in reaching variance investigation decisions. In particular, this research will examine within the conceptual framework discussed previously:

1) the effects of the decision situation structure, the available information set contents, the individual's information processing efficiency, and the individual's learning efficiency on the individual's long-run decision efficiency; and 2) the effects of the decision situation structure and the available information set contents on the individual's information processing and learning efficiency.

Selection of Independent Variables

The effects of two types of variables are of primary interest within this study: these are the situation variables and the process variables. The following discussion describes the selection of each of the variables employed in this study.

The situation variables

The situation variables are the quantity of information available to the individual prior to his decision, the statistical structure of the two states of nature, and the cost structure of the possible decision outcomes.

The available information set. The effects of the contents of the available information set are studied by manipulating the presence and absence of certain distributional information. This involves the specification of two levels of available information set content. Since the difficultly of the discrimination task may be increased by the absence of certain information, one level of the information variable has less distributional information than the other level. This independent variable is labeled the information variable.

The statistical structure. The effects of the statistical structure of the decision situation are studied by manipulating a distributional information variable. This involves the specification of two levels of statistical relationship among the two states. Since the difficulty of the discrimination task increases as the area of distributional overlap between the two states increases, one level of the distribution variable will have a greater area of overlap than will the other level. This independent variable is labeled the _distribution variable_. All other distributional information items, if presented, will be controlled as constants.

The cost structure. The effects of the cost structure of the possible decision outcomes are studied by manipulating a singular information variable. The manipulation of this variable involves the specification of two levels of decision outcome relationships (in terms of incurred costs). This independent variable is labeled the _cost variable_. Since the importance of the discrimination task increases as the costs associated with decision outcomes that involve decision errors become unequal, the different levels of the cost variable will be associated with different decision error costs. One level of the cost variable is structured in favor of more variance investigations and the other level of the cost variable is structured in favor of fewer variance investigations. The only other singular information variable, the actual results of the physical process and its cost variance, is the primary experimental stimulus. This information item will be a random variable whose distributions, given either of the two states of nature, will be normally shaped with parameter values defined by the appropriate level of the distribution variable.

Independent variables interaction. The research design of this study is a factorial design in which the above three independent variables, each at two levels, are fully crossed, thus producing eight (2^3) independent variables combinations or treatments. The factorial combination of the different levels of the independent variables adds power to the research design by permitting the examination of the effects of interactions upon the dependent variables.

The process variables

The effects of an individual's information processing and learning efficiency are studied using certain observation variables measured on a continuous (ratio) scale. Continuous measurement facilitates the use of these variables as both independent and dependent variables. When used as independent variables the measures are treated as random components rather than as discrete classification levels. The effects are studied using three major types of variables: 1) individual decision model sensitivity (relative effect of a variable response range), 2) individual decision criteria (relative effect of conservative adjustment), and 3) relative initial decision anchor and final decision anchor relationships. The first two types of variables are derived from model parameters within the theory of signal detection.

A summary of the general research design

The general research design is depicted in Table 1. The design is presented in terms of the dependent and independent variables to be included within the research. More specific extensions and

TABLE 1

GENERAL RESEARCH DESIGN IN TERMS OF EXPERIMENTAL VARIABLES

	Dependent Variables	
Independent Variables	Individual Long-Run Decision Efficiency	Individual Information Processing and Learning Efficiency
Contents of the available information set	X	X
Structure of the decision situation:		
Statistical relationships	X	X
Decision outcome relationships	X	X
Individual information processing and learning efficiency	X	

Note: An "X" within a cell indicates that the relationship of the variables concerned are included within the experimental design.

operationalizations of these concepts are discussed in a later section of this chapter. The objective at this point is to summarize in general terms the relationships which will be included within the experimental design.

General Research Methodology

Research methodology pertains to the general procedures or methods employed in conducting research. Two general methods are employed in this research-- simulation and laboratory experimentation. The major objective of the simulation is to produce hypotheses which will predict the behavior of human decision makers within the decision situation assumed by the simulation. The simulation is based upon assumptions derived from the conceptual development and from the general task environment of the laboratory experimentation. These assumptions and the task environment are discussed in greater detail in a later section of this chapter. The major objective of the laboratory experiment is to test the conceptual development (through the hypotheses derived by the simulation) of the effects of the various independent variables on the various observation variables.

The general and specific research design employed in the laboratory experiment is the same as that employed within the simulation. The major difference between the simulation and the laboratory experiment is the use of human subjects. This difference creates two major sources of incompatability between the simulation and the laboratory experiment. First, the simulation makes certain assumptions concerning human behavior and applies these assumptions consistently. Within

the laboratory experiment such behavior is not necessarily applied consistently. Consequently, greater variance of results is expected within the laboratory experiment than within the simulation. Second, it should be noted that certain variables are largely affected by individual attributes. Without a theory of the effect of individual attributes any simulation of these variables would be arbitrary. Accordingly, not all of the experimental variables are included in the simulation. Hypotheses concerning the variables not present within the simulation either are derived from limited concepts concerning the effects of individual attributes or are stated in an exploratory manner (no expected difference).

General Experimental Environment and Task

The standard cost variance investigation situation studied within this research is set in an environment of a manufacturing company. More specifically, the subjects are asked to assume the role of the operational manager of an assembly department which assembles a single product, a metal folding chair. The operating efficiency of the assembly department is determined completely by the labor efficiency of the assembly workers.

Each subject receives a sequential series of standard cost variance reports and is asked for each report to decide whether to investigate or not to investigate the reported labor efficiency variance. The efficiency of a subject's decision performance and the amount of payment he will receive for participating in the experiment is based upon the total investigation decisions cost which he incurs over the series of variance reports.

Each standard variance report is concerned with the results of a single job-order to produce a constant number of chairs and reports only aggregate (overall assembly department) results. Each report contains the aggregate standard assembly time allowed per chair, the actual assembly time incurred per chair, the overall labor efficiency variance per chair, the total number of chairs produced, and the costs associated with each possible decision in combination with each possible state of nature. All time units are presented in minutes. The singular information contained in a variance report is independent of that contained in previous variance reports.

The experiment is conducted in two phases-- a training phase and an experimental phase. The training phase consists of three contiguous sessions in which the subject learns his role and presumably develops his decision strategy. Performance feedback is given at the completion of each training session. The experimental phase consists of a single session in which the subject receives a series of variance reports similar to those presented in his training session. In this phase no performance feedback is given until after the completion of the entire experiment. The subject is paid according to his performance in the experimental phase.[3]

Operationalization of Variables

This research employs the following three decision situation independent variables, each measured using a discrete classification:

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[3]Greater detail concerning the experimental environment, task, and procedures is presented in Chapter V.

1) the information variable, 2) the distribution variable, and 3) the cost variable. As indicated previously, each is varied across two levels. The individual process variable types, measured on a continuous scale, include the following: 1) individual decision model sensitivity, 2) individual decision criteria, and 3) relative initial and final decision anchor relationships. The major dependent variable is the individual long-run decision efficiency (in terms of incurred costs). The following discussion describes each of the variables or variable types as they are employed in this study.

The information variable

The first level, labeled I1, is derived from the set of information assumed to come from individual experience with the physical system. It includes the following items: 1) the historically derived portion of time in which the process has been found to fall in each of the two states, 2) the assumption that the random variable of interest (actual minutes incurred per chair or its associated standard variance) is normally distributed for both states, 3) the lowest observed value of the random variable, 4) the highest observed value of the random variable, 5) the maximum costs associated with each state, and 6) the minimum costs associated with each state.

The second level of the information variable, labeled I2, includes additional distributional information. In addition to the six items contained in the I1 information set, the following two items are included: 1) the mean of the random variable within each state, and 2) the standard deviation of the random variable within each state.

The distribution variable

Manipulation of the distribution variable involves two factors: 1) the distributional parameters of each state, and 2) the statistical relationship between the states. The two levels of this variable are generated through a change in the variance and a change in the standardized distance between the means of the two states. The first level of the distribution variable, labeled S1, has the following parameters and relationships:

1) μ_{11} = 36.0 actual minutes incurred per chair;

2) $\sigma_{11} = \sigma_{12} = \sigma_1$ = 3.0 actual minutes incurred per chair; and

3) $\mu_{12} = \mu_{11} + 1.5\sigma_1$ = 40.5 actual minutes incurred per chair,

where, μ_{ij} = the mean of the jth state of nature (in-control = 1 and out-of-control = 2) given the ith distribution level (S1 = 1 and S2 = 2);

σ_{ij} = the standard deviation of the jth state of nature given the ith distribution level; and

σ_i = the standard deviation common to both states of nature given the ith distribution level.

The second level of the distribution variable, labeled S2, has the following parameters and relationships:

1) μ_{21} = 36.0 actual minutes incurred per chair;

2) $\sigma_{21} = \sigma_{22} = \sigma_2$ = 5.0 actual minutes incurred per chair; and

3) $\mu_{22} = \mu_{21} + 1.8\sigma_2$ = 45.0 actual minutes incurred per chair,

where μ_{ij}, σ_{ij}, and σ_i are defined the same as in the S1 level. The third and fourth statistical moments of each state within each distribution level are uncontrolled except that their deviations from a normal distribution are minimized.

The cost variable

Given the two states of nature (the realization of which is unknown to the individual) and two possible decisions, there follows that two types of errors can be made in reaching a decision. The first type of decision error, labeled type A, is the decision to investigate the physical process when the in-control state exists. The second type of decision error, labeled type B, is the decision not to investigate when the out-of-control state exists. The marginal cost of either error type equals the cost that would have been incurred had the correct decision been made minus the cost that was incurred by the incorrect decision. Thus, the marginal costs of the two decision error types, labeled MC_A and MC_B, are:

$$MC_A = C(\text{decision=not investigate} \mid \text{state=in-control}) - C(\text{decision=investigate} \mid \text{state=in-control}),$$ and

$$MC_B = C(\text{decision=investigate} \mid \text{state=out-of-control}) - C(\text{decision=not investigate} \mid \text{state=out-of-control}),$$

where C( ) represents the decision cost for the situation within the parentheses.

When the marginal cost of a type A error equals the marginal cost of a type B error the cost structure should be ignored when making an investigation decision. Of greater interest are situations in which the marginal error costs not equal. In the present study, each level of the cost variable takes one of the following forms: 1) the marginal cost of a type B decision error equals three times the marginal cost of a type A error (labeled level C1), and 2) the marginal cost of a type A error equals three times the marginal cost of a type B error (labeled level C2).

Individual decision model sensitivity variables

The sensitivity of the individual's decision model relative to the decision situation is measured using the TSD parameter d'. The theoretical definition of d' is:

$$d' = (\mu_2 - \mu_1)/\sigma = z_1 - z_2$$

where μ_j = the mean of the jth state of nature (in-control = 1 and out-of-control = 2);

σ = the common standard deviation of the states of nature; and

z_j = the value of the normal distribution function associated with the jth state of nature and any decision cutoff value common to both states.

An empirical estimate of the d' for an individual, labeled $\underline{d_i'}$, is obtained using the individual's conditional probabilities P(decision= investigate | state=out-of-control) and P(decision=investigate | state= in-control) to calculate a subjective z_1 and z_2. As previously pointed out, d' is relative to the decision situation. In particular, d' is relative to the distribution variable. To gain comparability across situations the following measure is used:

$$DN_i = d_i' \,/\, d_k'$$

where d_k' is generated using optimal model k. The measure decreases from a value of one as the result of several factors: 1) the individual is inconsistent in his use of his cutoff value (i.e., there exists a range around his cutoff value within which decisions are not made using a strict relation to this cutoff value) or the individual makes one or more temporary processing errors, and 2) the individual utilizes more than one cutoff value.

Based upon a subjective analysis of each individual's decisions, the measure DN_i can be adjusted for the effects of using multiple cutoff values. Defining $d_i'^{a}$ to be the individual's decision model sensitivity with the effects of multiple cutoff values eliminated:

$$DNA_i = d_i'^{a} / d_k'$$

The difference $DNA_i - DN_i$ approaches zero as the effects of multiple cutoff values decreases and becomes zero when the individual uses a single cutoff value.

Individual decision criteria variables

The criteria the individual adopts in making his decisions are measured using the TSD parameter β. The theoretical definition of β is:

$$\beta = \phi(z_2) / \phi(z_1)$$

where $\phi(\ )$ denotes the normal density function for the point in the parentheses and z_j is defined the same as for the d_i' variable.

An empirical estimate for the β of an individual, labeled β_i, is obtained using the z_1 and z_2 values associated with the individual's conditional probabilities employed in estimating d_i'. The measure β_i is relative to the decision situation. In particular, it is relative to those variables which affect the point on the decision axis which the individual selects as his investigation decision cutoff value. A measure of individual criteria comparable across situations is defined as:

$$BN_i = \beta_i / \beta_k$$

where β_k is generated using optimal model k. The measure approaches a value of one as β_i approaches β_k (i.e., as the individual's cutoff decision value approaches the optimal model's cutoff decision value).

The measure approaches either a value of zero or positive infinity as the result of several factors: 1) the individual does not process properly the effects of the relative costs of the two types of decision errors, 2) the individual does not process properly the effects of the relative frequencies of the two states, and 3) the individual uses more than one cutoff value.

Using the same subjective analysis as that used in adjusting the DN_i measure, the BN_i measure can be adjusted for the effects of multiple cutoff values. Defining β_i^a to be the individual's criteria measure with the effects of multiple cutoff values eliminated:

$$BNA_i = \beta_i^a / \beta_k$$

The difference $BNA_i - BN_i$ approaches a value of zero as the effects of multiple cutoff values decrease and becomes zero when the individual uses a single cutoff value.

Another measure derived from the BN_i measure can be considered a measure of individual conservatism. In this study, conservatism refers to incomplete adjustment from an initial decision anchor towards the optimal cutoff value. Non-conservatism refers to a more that complete adjustment from the initial decision anchor past the optimal cutoff value. The extent of conservatism is measured by the relative distance between the individual's cutoff value and the optimal model's cutoff value. Since the measure is dependent on the direction of adjustment it is conditional upon the level of the cost variable. Using BNC_i to denote the extent of an individual's conservatism:

$$BNC_i = (\beta_i^a - \beta_k) / \beta_k \qquad \text{given the C1 cost level; and}$$

$$BNC_i = (\beta_k - \beta_i^a) / \beta_k \qquad \text{given the C2 cost level.}$$

BNC_i approaches either positive infinity or a value of one as the extent of conservatism increases, approaches a value of zero as the extent of conservatism decreases, and approaches either a value of negative one or negative infinity as the extent of non-conservatism increases.

Initial and final decision anchor variables

The relative relationships between an individual's initial and final decision anchors can be measured in terms of the relative linear distance between these two decision anchors. A measure of the relative adjustment for individual i, labeled RA_i, is conditional on the direction of adjustment along the relevant decision axis. This direction of adjustment is in turn conditional on the level of the cost variable. Given the C1 cost level the initial decision anchor is greater than the optimal model cutoff value, and given the C2 cost level the initial decision anchor is less than the optimal model cutoff value. The RA_i measure is defined as:

$RA_i = (EDV_i - ODV_k) / (TDV_i - ODV_k)$,given the C1 cost level;

$RA_i = (ODV_k - EDV_i) / (ODV_k - TDV_i)$,given the C2 cost level,

where EDV_i = individual i's final (experiment) decision anchor;

TDV_i = individual i's initial (training) decision anchor; and

ODV_k = optimal model k's final (experiment) cutoff value.

The RA_i measure has the following relationships: 1) if no adjustment occurs between the training and the experiment phases the measure will equal a value of one, 2) if the adjustment is in the wrong direction (away from the optimal model's experiment cutoff value) the measure will be greater than a value of one, 3) if the adjustment is in

the proper direction but incomplete the measure will be less than a value of one but greater than a value of zero, 4) if the adjustment is in the proper direction and is complete the measure will equal a value of zero, and 5) if the adjustment is in the proper direction but more than complete the measure will be less than a value of zero.

Individual long-run decision efficiency

A major dependent variable of interest in this research is the cost incurred as a result of the individual's variance investigation decisions. The experimental objective function for all decision situations is to minimize these costs (labeled investigation decisions costs). The individual's long-run decision efficiency is measured in terms of his minimization of the investigation decisions costs summed over all decisions.

Given a pair of decision situations which hold constant all of the independent variables except for the cost variable, the correct decision within each situation will lead to different investigation decisions costs. Consequently, absolute investigation decisions costs are not comparable between decision situations: a relative measure must be obtained. One such relative measure involves the comparison of the individual's investigation decision costs with that of an optimal model which uses the same information as that available to the individual. Denoting such a measure G_{ij}:

$$G_{ij} = (IC_{ij} - MC_{kj}) / SMC_k$$

where IC_{ij} = individual i's investigation decision cost for decision j;

MC_{kj} = optimal model k's investigation decision cost for decision j; and

SMC_k = the sum of optimal model k's investigation decisions costs over all decisions (m in number).

The G_{ij} measure can be classified into one of three submeasures where the classification is dependent upon the algebraic sign of G_{ij}. The classifications are 1) $G_{ij} > 0$-- the individual's investigation decision cost for decision j is greater than that of the optimal model, 2) $G_{ij} = 0$-- the individual's investigation decision cost for decision j is equal to that of the optimal model, and 3) $G_{ij} < 0$-- the individual's investigation decision cost for decision j is less than that of the optimal model.

Summing those G_{ij}s with identical algebraic signs, the summations are defined as follows:

GP_i = the sum of those G_{ij}s with a positive algebraic sign;

GN_i = the sum of those G_{ij}s with a negative algebraic sign; and

GZ_i = the sum of those G_{ij}s with a value of zero.

It is easily shown that the following relation holds:

$$\sum_{j=1}^{m} G_{ij} = GP_i + GN_i + GZ_i$$

where m equals the total number of decisions made by individual i. Since the GZ_i summation equals zero, the sum of the G_{ij} over all j = 1,m decisions, denoted G_i, is:

$$G_i = GP_i + GN_i$$

Conceptually, GP_i is the relative additional cost of those decisions made by individual i which are greater in value than that of the optimal model. The GN_i is the relative savings of those decisions made by individual i which are less in value than that of the optimal model.

The anchoring and adjustment process may occur over three training sessions and one experiment session. Using the first training session as an estimate of the initial decision anchor and the experiment session as an estimate of the final decision anchor, there remains two training sessions within which the adjustment process itself can be analyzed. In particular, the effects of the pattern of adjustments within the training sessions are expected to influence significantly the magnitude of an individual's experiment G_i measure. The adjustment process can be measured in the training sessions by computing the individual's G_i measure at the completion of each session. The measures, labeled TG_{i1}, TG_{i2}, and TG_{i3}, are defined in the same manner as the G_i measure discussed above (with the exception that they are computed from the appropriate training session data instead of the experiment session data). The differences between these training measures reflect the effects of the individual's adjustments in the training sessions. These differences are defined as follows:

$$DTG_{i1} = TG_{i1} - TG_{i2}$$

$$DTG_{i2} = TG_{i2} - TG_{i3}$$

where, DTG_{ij} = the difference between the G_i measure for the jth and the jth + 1 training sessions of individual i; and

TG_{ij} = the G_i measure for the jth training session of individual i.

Negative DTG_{ij} values indicate an increase in the TG_{ij} measure between training sessions, and positive DTG_{ij} values indicate the reverse.

The effects of the directions of these adjustments should be related to the effects of the final anchor on the individual's G_i measure (in the experiment). The effects of the adjustment measures

on the experiment measure can be analyzed using a discrete classification of the direction of the adjustments. This classification of the measure is accomplished using its algebraic sign. The second and third training session results can be grouped into one of four classes: PP(+,+), PM(+,-), MP(-,+), and MM(-,-). Subjects within the MM classification have constantly increasing TG_{ij} measures and subjects within the PP classification have constantly decreasing TG_{ij} measures.

Hypotheses Formation

As previously discussed, the formation of the experimental hypotheses is accomplished primarily using the method of simulation. Two general types of simulations are performed-- simulation of optimal model performances and simulation of subjective investigation decision performances. The first part of this section discusses the assumptions and presents the results of the simulation of optimal model performances. The second part of this section discusses certain assumptions derived from the conceptual development that form the basis for the simulation of subjective investigation decision performances. It also presents the results of this simulation and the derivation of the experimental hypotheses.

Simulation of Optimal Model Performances

The decision rule of the optimal model (given the objective function of minimizing incurred costs) employed in this research is to investigate the reported labor efficiency variance when:

$$\frac{P(x|out)}{P(x|in)} > \frac{P(in)}{P(out)} \cdot \frac{V_{in,N} - V_{in,Y}}{V_{out,Y} - V_{out,N}} \qquad \text{Equation 1}$$

where x = the actual minutes incurred per chair;

out = the state of out-of-control;

in = the state of in-control;

$V_{in,N}$ = the cost associated with not investigating an in-control variance;

$V_{in,Y}$ = the cost associated with investigating an in-control variance;

$V_{out,Y}$ = the cost associated with investigating an out-of-control variance; and

$V_{out,N}$ = the cost associated with not investigating and out-of-control variance.

The manipulation of the cost variable produces a constant cost ratio at each of the two levels of this variable. When the cost variable level is C1 the constant cost ratio is equal to one-third, and when the cost variable level is C2 the constant cost ratio is equal to three. The optimal model investigation decision rule expressed in equation 1 can be restate as:

$$LR_o > PR_i \cdot CR \qquad \text{Equation 2}$$

where LR_o = the likelihood odds of the reported labor efficiency variance being out-of-control $(P(x|out)/P(x|in))$;

PR_i = the prior odds of the in-control state $(P(in)/P(out))$; and

CR = the constant cost ratio associated with the appropriate level of the cost variable.

Assuming that both states of nature are normally distributed with equal variance the optimal model investigation decision rule expressed in

equation 2 can be restated in the following mathematical terms:

$$\frac{\exp -(x - \mu_2)^2/2\sigma^2}{\exp -(x - \mu_1)^2/2\sigma^2} > PR_i \cdot CR$$

where x = actual minutes incurred per chair;

μ_1 = the mean of the in-control state;

μ_2 = the mean of the out-of-control state;

σ = the common standard deviation of both states; and

exp = the notation for the exponential funcition (e).

If the above equation was changed to an equality and solved for x the result would be the optimal cutoff value in terms of actual minutes incurred. This solution takes the general form:

$$x = \frac{\sigma^2(\ln(PR_i) + \ln(CR))}{\mu_2 - \mu_1} + 0.50(\mu_2 + \mu_1) \qquad \text{Equation 3}$$

where x = the optimal cutoff value in terms of actual minutes incurred; and

ln = the notation for the natural logarithm function ($\log_e$).

With the decision rule in the form of equation 3 the parameters required to fit the optimal model become identifiable. These parameters include the mean of both states of nature, the common variance of the two states, the prior odds of the in-control state, and the appropriate value of the cost ratio.

With knowledge of the parameters required to fit the optimal model the criteria employed for the simulation of optimal model performances can be discussed. The first criterion is that information available to the optimal model be the same as the information available to the individual. The information available to the individual is manipulated by the levels of the information variable. Within the I2

information level the available information set contains statistical estimates of all the parameters required to fit the optimal model. However, within the I1 information level the available information set does not contain all the required parameter estimates. Therefore, within the I1 information level the optimal model must use the training sessions to estimate the missing parameters. The parameter estimates, both given and estimated, are presented in Table 2.

The second criterion is that the labor efficiency variance reports presented to the subjects in the experiment be the same reports used in the simulation of optimal model performances. The appropriate parameter estimates presented in Table 2 were used in the optimal model decision rule expressed by equation 2 to simulate optimal model investigation decisions. Table 3 presents some performance results of this optimal model simulation.

Simulation of Subjective Investigation Decision Performances

This section discusses assumptions derived from the conceptual development that form the basis for the simulation of subjective investigation decision performances. It also presents the results of this simulation and the derivation of the experimental hypotheses.

Assumptions of simulation

The first assumption employed for the simulation of subjective investigation decision performances is that the subjects will behave as if they use the anchoring and adjustment heuristic during the training phase. The anchoring and adjustment heuristic proposes that

TABLE 2

ESTIMATES OF THE PARAMETERS REQUIRED TO FIT THE OPTIMAL MODEL GIVEN THE VARIOUS CONDITIONS

Cost Variable	Parameter Estimate	Experimental Parameters: Information Variable I1, Distribution Variable S1	Experimental Parameters: Information Variable I1, Distribution Variable S2	Experimental Parameters: Information Variable I2, Distribution Variable S1	Experimental Parameters: Information Variable I2, Distribution Variable S2	Actual Underlying Data Structure Parameters, Distribution Variable S1	Actual Underlying Data Structure Parameters, Distribution Variable S2
C1	μ_1	35.99	36.26	36.00	36.00	35.975	35.943
	μ_2	40.21	44.24	40.50	45.00	40.492	44.995
	σ_1^2	8.88	29.42	9.00	25.00	9.157	25.060
	σ_2^2	7.38	19.32	9.00	25.00	9.437	25.002
	PR_i	1.50	1.50	1.50	1.50	1.500	1.500
	CR	0.33	0.33	0.33	0.33	0.333	0.333
C2[a]	CR	3.00	3.00	3.00	3.00	3.000	3.000

[a]The parameter estimates for $\mu_1, \mu_2, \sigma_1^2, \sigma_2^2$, and PR_i given the C2 cost level are the same as those given the C1 cost level.

TABLE 3

RESULTS OF THE SIMULATION OF OPTIMAL MODEL PERFORMANCES GIVEN THE VARIOUS CONDITIONS

k	Information	Distribution	Cost	P(investigate out-of-control)	P(investigate in-control)	Optimal Cutoff Value (actual minutes incurred)	d'_k	β_k
1	I1	S1	C1	0.875	0.383	36.90	1.447	0.539
2	I1	S1	C2	0.400	0.033	41.29	1.581	5.206
3	I1	S2	C1	0.875	0.300	38.70	1.674	0.592
4	I1	S2	C2	0.425	0.017	45.88	1.939	9.453
5	I2	S1	C1	0.900	0.400	36.86	1.535	0.454
6	I2	S1	C2	0.400	0.033	41.26	1.581	5.206
7	I2	S2	C1	0.900	0.300	38.57	1.806	0.504
8	I2	S2	C2	0.525	0.033	44.68	1.897	5.364

a subject will select an initial anchor as a first decision approximation and will adjust this decision anchor toward an optimally correct point as he learns from his experiences with the states of nature. However, the individual's adjustment process will not be sufficient: i.e., he will tend to approach the optimally correct point but will not adjust completely to that point.

The second assumption is that the location of the initial decision anchor on the actual minutes incurred continuum (axis) will be conditional upon the level of the distribution variable. The reason for this is that the initial decision anchor is expected to be located at a central point between the means of the two states. Since the mean of the out-of-control distribution shifts with the level of the distribution variable, the central point between the means of the two states also shifts with the level of the distribution variable. The initial decision anchor used in the simulation of subjective investigation decision performances is the geometric intersection point of the two states' distribution curves. This particular initial decision anchor is used because it is the exact central point between the means of the two states. However, it is selected for operational purposes and is not necessary to the conceptual development. Any point of central tendency would be satisfactory.

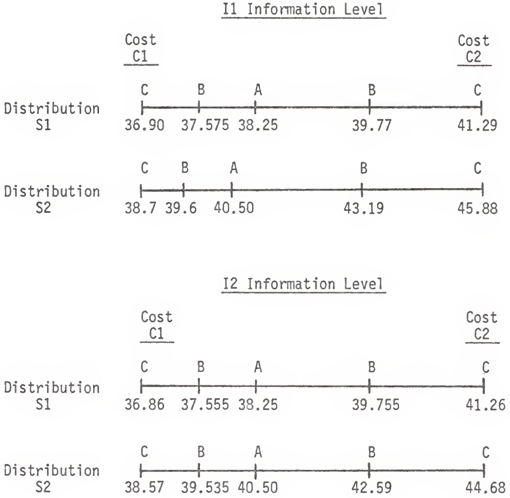
The final assumption is that the subjects' adjustment process will be approximately equal over the various treatment conditions. The adjustment process is defined as a linear movement along the actual minutes incurred axis from the initial decision anchor towards the appropriate optimal model decision cutoff. The magnitude of the linear movement used in the simulation of subjective investigation decision

performances is 50 percent of the distance between the initial decision anchor and the appropriate optimal decision value. The 50 percent adjustment value, selected for operational purposes, is completely arbitrary and is not necessary to the conceptual development. The only restriction is that it be less than 100 percent. Furthermore, the general assumption of equal adjustment over the various conditions is not necessary to the conceptual development: the objective of this general assumption is to facilitate a simple operationalization of the simulation.

Training phase simulation and hypotheses formation

The first stage of the simulation involves simulating the anchoring and adjustment process in the training sessions for each combination of independent variables. A simulated subject sample size of one is used for each condition (resulting in a total simulated subject sample of eight). The results of this first stage simulation are presented in graphical form in Figure 2. This figure depicts the simulated initial decision anchors (points A), the simulated final decision anchors (points B), and the simulated optimal cutoff values (points C) for each of the eight combinations of independent variables.

The assumptions used in simulating the training phase can be investigated using the results of the experimental training phase. The assumptions are 1) that the subjects will behave as if they used the anchoring and adjustment heuristic, 2) that the initial decision anchor will be located centrally between the means of the two states and will be dependent on the level of the distribution variable, and 3) that the



Note: All scales are actual minutes incurred per chair produced.

FIGURE 2

SIMULATED INITIAL DECISION ANCHORS (POINTS A), FINAL DECISION ANCHORS (POINTS B), AND OPTIMAL CUTOFF VALUES (POINTS C)

adjustment process will be approximately equal over the various conditions. The location of the initial decision anchor can be investigated by examining the relationship between the individual's initial cutoff value (in the first training session) and the intersection point of the appropriate two distribution curves (the TDV_i measure). These intersection points are conditional upon the level of the distribution variable. Given the S1 distribution level the intersection point is 38.25 actual minutes incurred, and given the S2 distribution level the intersection point is 40.5 actual minutes incurred (see Figure 2 for a graphical presentation of these points). The expected relationship is that the mean initial decision anchor (TDV_i) of the individuals, given a level of the distribution variable, will not be significantly different from the intersection point of the appropriate two distribution curves.

The assumption of approximately equal adjustment over the various conditions can be investigated by examining the relationship between the individual's adjustment over the complete experiment and the total adjustment that would be required to reach the optimal model's decision cutoff value. A measure of the relative adjustment for individual i, RA_i, is conditional upon the direction of adjustment along the relevant decision axis (i.e., the actual minutes incurred per chair produced). The expected relationship is that the mean RA_i will not differ significantly between the levels of the various conditions.

Given the above simulation and discussion the following hypotheses can be derived:

H1.1a $(\overline{TDV_i}|S1) = 38.25.$

The mean initial decision anchor given the S1 distribution level

will equal the intersection point of the two distribution curves within that level.

H1.1b $(\overline{TDV_i}|S2) = 40.5$.

The mean initial decision anchor given the S2 distribution level will equal the intersection point of the two distribution curves within that level.

H1.2a $(\overline{TDV_i}|I1) = (\overline{TDV_i}|I2)$.

The mean initial decision anchor given the I1 information level will equal the mean initial decision anchor given the I2 information level.

H1.2b $(\overline{TDV_i}|C1) = (\overline{TDV_i}|C2)$.

The mean initial decision anchor given the C1 cost level will equal the mean initial decision anchor given the C2 cost level.

H1.3a $(\overline{RA_i}|I1) = (\overline{RA_i}|I2)$.

The mean relative adjustment given the I1 information level will equal the mean relative adjustment given the I2 information level.

H1.3b $(\overline{RA_i}|S1) = (\overline{RA_i}|S2)$.

The mean relative adjustment given the S1 distribution level will equal the mean relative adjustment given the S2 distribution level.

H1.3c $(\overline{RA_i}|C1) = (\overline{RA_i}|C2)$.

The mean relative adjustment given the C1 cost level will equal the mean relative adjustment given the C2 cost level.

Individual decision model sensitivity hypotheses formation

The measures of individual decision model sensitivity should generally be unaffected by the independent variables. These measures

have a greater relationship with individual decision processes than with the specific conditions of a general decision situation. The individual decision model sensitivity measure d'_i should have a relationship with the distribution variable only. The theoretical d' measure under the S1 distribution level is 1.5 and under the S2 distribution level is 1.8. Thus, the average d'_i under the S2 distribution level should be greater than under the S1 distribution level.

The DNA_i measure should have no systematic relationships with the three independent variables. This measure of the relative deviation of the individual's decision model sensitivity from that of the optimal model's generally is due to individual decision inconsistencies and temporary processing errors. If individuals are randomized into the specific decision situations there are no a priori reasons for expecting significant differences in this measure due to the independent variables.

The difference between DNA_i and DN_i measures the effects of multiple decision anchors upon the individual's relative decision model sensitivity. Relationships between this difference and the independent variables depend upon whether the independent variables are related to the causes underlying an individual's use of more than one cutoff value. A possible explanation involves the distribution variable. As the variance of the in-control state increases the absolute distance between the lowest values of the random variable of interest (actual minutes incurred) and the mean of the in-control state increases. In turn, as this distance increases subjects may be more inclined to perceive that a second out-of-control distribution overlaps the lower range of the in-control state. If such perceptions underly

the use of multiple cutoff values, the average difference between DNA_i and DN_i should differ between the two levels of the distribution variable. A second possible explanation involves the cost variable. As the individual's final cutoff value increases, the absolute distance between the individual's final cutoff value and the lowest values of the random variable of interest increases. In turn, as this distance increases subjects again may be more inclined to perceive that a second out-of-control distribution overlaps the lower range of the in-control state. If such perceptions underly the use of multiple cutoff values, the average difference between DNA_i and DN_i should differ between the two levels of the cost variable.

Based on the above discussion the effects of the independent variables on the individual decision model sensitivity measures can be hypothesized as follows:

H2.1a $(\overline{d}_i' \mid S1) < (\overline{d}_i' \mid S2)$.

Those subjects within the S1 distribution level will have significantly smaller mean d_i's then those subjects within the S2 level.

H2.1b $(\overline{d}_i' \mid I1) = (\overline{d}_i' \mid I2)$.

Those subjects within the I1 information level and within the I2 information level will have equal mean d_i's.

H2.1c $(\overline{d}_i' \mid C1) = (\overline{d}_i' \mid C2)$.

Those subjects within the C1 cost level and within the C2 cost level will have equal mean d_i's.

H2.2a $(\overline{DNA}_i \mid I1) = (\overline{DNA}_i \mid I2)$.

Those subjects within the I1 information level and within the I2 information level will have equal mean DNA_is.

H2.2b $(\overline{DNA_i}|S1) = (\overline{DNA_i}|S2)$.

Those subjects within the S1 distribution level and within the S2 distribution level will have equal mean DNA_is.

H2.2c $(\overline{DNA_i}|C1) = (\overline{DNA_i}|C2)$.

Those subjects within the C1 cost level and within the C2 cost level will have equal mean DNA_is.

H2.3a $(\overline{DNA_i-DN_i}|S1) < (\overline{DNA_i-DN_i}|S2)$.

Those subjects within the S1 distribution level will have significantly smaller mean DNA_i-DN_is than will those subjects within the S2 distribution level.

H2.3b $(\overline{DNA_i-DN_i}|C1) < (\overline{DNA_i-DN_i}|C2)$.

Those subjects within the C1 cost level will have significantly smaller mean DNA_i-DN_is than will those subjects within the C2 cost level.

Individual decision criteria simulation and hypotheses formation

The variables which affect the BN_i measure should be those factors related to the individual's selection of a cutoff value. The most significant variable affecting the individual's cutoff value should be the cost variable. Within this variable the initial decision anchor given the C1 level is much closer to the optimal cutoff value than is the initial decision anchor given the C2 level. Consequently, the BN_i measure should be closer to a value of one under the C1 level than under the C2 level.

The difference between the BNA_i and the BN_i measures should relate to the same variables as those discussed for the difference

between the DNA_i and DN_i measures. The two possible explanations include the distribution variable and the cost variable.

Theoretically, the more extreme the optimal cutoff value relative to a central point between the distributions of the two states, the higher should be the individual conservatism. The decision situations with the most extreme optimal cutoff values are those within the C2 cost level; the situations with the least extreme optimal cutoff values are those within the C1 cost level. Consequently, the BNC_i measure should be larger within the C2 cost level than within the C1 cost level.

The simulation and assumptions used in developing the training phase hypotheses can be extended to enable formation of hypotheses concerning the individual decision criteria. The earlier simulation derived the following final decision cutoff values: 1) 37.555 actual minutes incurred for the C1 cost level given the I2 information level and the S1 distribution level, and 2) 39.755 actual minutes incurred for the C2 cost level given the I2 information level and the S1 distribution level. Given these cutoff values a $f(\beta_i^a)$ measure can be calculated directly (the β_i^a measure is used rather than the β_i measure due to the assumption of a single cutoff value). The functional notation, f( ), is employed to indicate these estimates are based upon a simulation rather than upon empirical observation. For this simulation the $f(\beta_i^a)$s are as follows:

$$f(\beta_i^a|C1,S1,I2) = \phi(z_{out}) \;/\; \phi(z_{in}) = 0.70818$$

$$f(\beta_i^a|C2,S1,I2) = \phi(z_{out}) \;/\; \phi(z_{in}) = 2.11774$$

where $\phi(\ )$ indicates the value of the normal density function at the point in parentheses. Given the $f(\beta_i^a)$ measures the $f(BNA_i)$ measures can be calculated. For this simulation the $f(BNA_i)$s are as follows:

$f(BNA_i|C1,S1,I2) = f(\beta_i^a) \,/\, f(\beta_k) = 1.41898$

$f(BNA_i|C2,S1,I2) = f(\beta_i^a) \,/\, f(\beta_k) = 0.47017$

where $f(\beta_k)$ is the simulated β_k measure at the cutoff value of the kth optimal model.

This simulation can be extended to the S2 level of the distribution variable given the I2 information level and can be extended to both the S1 and S2 levels of the distribution variable given the I1 information level. The $f(BNA_i)$ measures obtained under the I2 information and S2 distribution conditions are as follows:

$f(BNA_i|C1,S2,I2) = 1.42318$

$f(BNA_i|C2,S2,I2) = 0.47300$

The $f(BNA_i)$ measures given the I1 information level are as follows:

$f(BNA_i|C1,S1,I1) = 1.40126$

$f(BNA_i|C2,S1,I1) = 0.46993$

$f(BNA_i|C1,S2,I1) = 1.38273$

$f(BNA_i|C2,S2,I1) = 0.38094$

Based on these $f(BNA_i)$ measures, hypotheses can be derived concerning the effects of the independent variables upon the BNA_i measure. The $f(BNA_i)$ measures can be averaged over the appropriate conditionals to determine these effects. Averaging over all conditionals except the information variable gives the following results:

$f(\overline{BNA}_i|I1) = 0.90871$

$f(\overline{BNA}_i|I2) = 0.94633$

Although there is a difference in the $f(BNA_i)$ measures due to the information variable this difference is small compared to the standard error of these estimates (the difference divided by the standard error is 0.03762/0.39157 = 0.0961). Therefore, a significant effect due to the information variable would not be expected.

Averaging over all conditionals except the distribution variable gives the following results:

$f(\overline{BNA_i}|S1) = 0.94009$

$f(\overline{BNA_i}|S2) = 0.91496$

Again, the difference in the $f(BNA_i)$ measures due to the distribution variable is small compared to the standard error of the estimates (the difference divided by the standard error is 0.02513/0.39174 = 0.0642). A significant effect due to the distribution variable would not be expected.

Averaging over all conditionals except the cost variable gives the following results:

$f(\overline{BNA_i}|C1) = 1.40654$

$f(\overline{BNA_i}|C2) = 0.44851$

The difference in the $f(BNA_i)$ measures due to the cost variable is large compared to the standard error of the estimates (the difference divided by the standard error is 0.95803/0.02436 = 39.3308). Consequently, a significant effect would be expected for the cost variable.

Another implication drawn from the $f(BNA_i)$ measures concerns the homogeneity of variance for the measures given different levels of the cost variable. The variance for the $f(BNA_i|C1)$ is .00034 and the variance for the $f(BNA_i|C2)$ is .00203. Using the F test for equal variances, F=5.9344 (3 and 3 d.f.) which indicates the variances may not be equal. The variance of $(BNA_i|C1)$ would be expected to be less than the variance of $(BNA_i|C2)$.

This simulation can be extended to enable the formation of hypotheses concerning the effects of the independent variables on the

conservatism measure BNC_i. This extension employs the $f(\beta_i^a)$ and $f(\beta_k)$ measures used above. The results of this extended simulation averaged over all conditionals except for the information variable are as follows:

$f(\overline{BNC_i}|I1) = 0.48328$

$f(\overline{BNC_i}|I2) = 0.47475$

The difference in the $f(\overline{BNC_i})$ measures due to the information variable is small compared to the standard error of the estimates (the difference divided by the standard error is 0.00853/0.06390 = 0.1335). A significant effect due to the information variable would not be expected.

Averaging over all conditionals except for the distribution variable gives the following results:

$f(\overline{BNC_i}|S1) = 0.47004$

$f(\overline{BNC_i}|S2) = 0.48799$

The difference in the $f(\overline{BNC_i})$ measures due to the distribution variable is small compared to the standard error of the estimates (the difference divided by the standard error is 0.01795/0.06357 = 0.2824). A significant effect due to the distribution variable would not be expected.

Finally, averaging over all conditionals except for the cost variable gives the following results:

$f(\overline{BNC_i}|C1) = 0.40654$

$f(\overline{BNC_i}|C2) = 0.55149$

The difference in the $f(\overline{BNC_i})$ measure due to the cost variable is large compared to the standard error of the estimates (the difference divided by the standard error is 0.14495/0.02436 = 5.9503). Consequently, a significant effect would be expected for the cost variable.

The above discussion concerning the individual decision criteria measures can be summarized as follows:

H3.1a $(\overline{BNA_i}|I1) = (\overline{BNA_i}|I2)$.

The mean BNA_i of those subjects within the I1 information level and within the I2 information level will be equal.

H3.1b $(\overline{BNA_i}|S1) = (\overline{BNA_i}|S2)$.

The mean BNA_i of those subjects within the S1 distribution level and within the S2 distribution level will be equal.

H3.1c $(\overline{BNA_i}|C1) > (\overline{BNA_i}|C2)$.

Those subjects within the C1 cost level will have a significantly larger mean BNA_i than will those subjects within the C2 level.

H3.2 $\sigma^2(BNA_i|C1) < \sigma^2(BNA_i|C2)$.

The BNA_i of those subjects within the C1 cost level will have a significantly smaller variance than will the BNA_i of those subjects within the C2 cost level.

H3.3a $(\overline{BNC_i}|I1) = (\overline{BNC_i}|I2)$.

The mean BNC_i of those subjects within the I1 information level and within the I2 information level will be equal.

H3.3b $(\overline{BNC_i}|S1) = (\overline{BNC_i}|S2)$.

The mean BNC_i of those subjects within the S1 distribution level and within the S2 distribution level will be equal.

H3.3c $(\overline{BNC_i}|C1) < (\overline{BNC_i}|C2)$.

The mean BNC_i of those subjects within the C1 cost level will be significantly smaller than the mean BNC_i of those subjects within the C2 level.

H3.4a $(\overline{BNA_i - BN_i} | S1) < (\overline{BNA_i - BN_i} | S2)$.

The mean BNA_i-BN_i of those subjects within the S1 distribution level will be significantly smaller than the mean BNA_i-BN_i of those subjects within the S2 distribution level.

H3.4b $(\overline{BNA_i - BN_i} | C1) < (\overline{BNA_i - BN_i} | C2)$.

The mean BNA_i-BN_i of those subjects within the C1 cost level will be significantly smaller than the mean BNA_i-BN_i of those subjects within the C2 cost level.

Individual long-run decision efficiency simulation and hypotheses

The simulation and assumptions used in developing the training phase hypotheses enable the formation of hypotheses concerning the G_i variable. The graph presented in Figure 3 depicts the relations of the values derived within the training phase simulation given the condition (I2,S1). The interval between the final cutoff value and the appropriate optimal model cutoff value represents the areas associated with the G_i measure. For the C1 cost level the area of the interval under the in-control distribution is the area associated with the GN_i measure; the area of the interval under the out-of-control distribution is the area associated with the GP_i measure. These areas are the left-most shaded areas in Figure 3. For the C2 cost level the area of the interval under the out-of-control distribution is the area associated with the GN_i measure; the area of the interval under the in-control distribution is the area associated with the GP_i measure. These areas are the right-most shaded areas in Figure 3. The areas under these curves for this simulation are as follows:

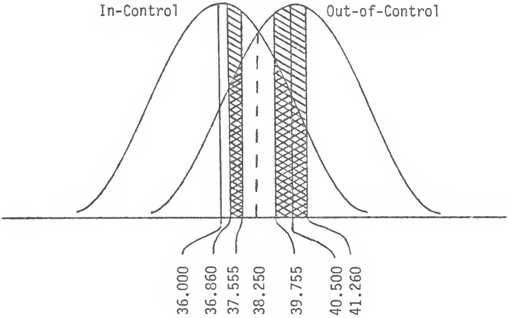


FIGURE 3

GRAPH OF THE SIMULATION USED IN THE CONDITION
(I2 INFORMATION, S1 DISTRIBUTION)

$\text{Area}(GN_i|C1,S1,I2) = 0.08483$

$\text{Area}(GP_i|C1,S1,I2) = 0.05048$

$\text{Area}(GN_i|C2,S1,I2) = 0.19780$

$\text{Area}(GP_i|C2,S1,I2) = 0.06549$

These areas must be adjusted for the relative frequency differences and the relative cost differences between the various conditions. If the in-control distribution is given a relative frequency weight of one,then the relative frequency weight of the out-of-control distribution would equal two-thirds (P(in-control) = 0.60 and P(out-of-control) = 0.40). The relative cost weights can be obtained directly from the manipulation of the cost variable. Given the C1 cost level, errors under the out-of-control distribution equal three times the errors under the in-control distribution. Given the C2 cost level, errors under the in-control distribution are equal to three times the errors under the out-of-control distribution. The four areas associated with the various G_i measures can be converted into relative relations by taking into account both of these relative weights (frequency and cost). These relative relations are as follows:

$f(GN_i|C1,S1,I2) = (0.08483)\cdot(1)\cdot(1) = 0.08483$

$f(GP_i|C1,S1,I2) = (0.05048)\cdot(2/3)\cdot(3) = 0.10096$

$f(GN_i|C2,S1,I2) = (0.19780)\cdot(2/3)\cdot(1) = 0.13187$

$f(GP_i|C2,S1,I2) = (0.06549)\cdot(1)\cdot(3) = 0.19647$

The difference between the relative relations of GP_i and GN_i given a level of the cost variable indicates the relative effect of these intervals upon the G_i measure. The differences for this simulation are as follows:

$$f(G_i|C1,S1,I2) = f(GP_i|C1,S1,I2) - f(GN_i|C1,S1,I2)$$
$$= 0.10096 - 0.08483 = 0.01613$$
$$f(G_i|C2,S1,I2) = f(GP_i|C2,S1,I2) - f(GN_i|C2,S1,I2)$$
$$= 0.19647 - 0.13187 = 0.06460$$

This simulation can be extended to the S2 level of the distribution variable given the I2 information level and can be extended to both the S1 and S2 distribution levels given the I1 information level. The relative relations of the G_i measure obtained under the I2 information and S2 distribution conditions are as follows:

$$f(G_i|C1,S2,I2) = 0.07596 - 0.06385 = 0.01211$$
$$f(G_i|C2,S2,I2) = 0.15741 - 0.10639 = 0.05102$$

The relative relations for the G_i measure given the I1 information level are as follows:

$$f(G_i|C1,S1,I1) = 0.09942 - 0.08230 = 0.01712$$
$$f(G_i|C2,S1,I1) = 0.19629 - 0.13146 = 0.06483$$
$$f(G_i|C1,S2,I1) = 0.07246 - 0.05884 = 0.01362$$
$$f(G_i|C2,S2,I1) = 0.15342 - 0.14078 = 0.01264$$

Based upon these relative relations hypotheses can be derived concerning the effects of the independent variables on the G_i measure. These relations can be averaged over the appropriate conditionals to determine the effects. Averaging over all conditionals except the information variable gives the following results:

$$f(\overline{G}_i|I1) = 0.02705$$
$$f(\overline{G}_i|I2) = 0.03596$$

Although there is a difference in the $f(\overline{G}_i)$ due to the information variable,this difference is small compared to the standard error of the estimates (the difference divided by the standard error is

0.0089/0.01808 = 0.49226). Therefore, a significant effect due to the information variable would not be expected.

Averaging over all conditionals except the distribution variable gives the following results:

$f(\overline{G}_i|S1) = 0.04152$

$f(\overline{G}_i|S2) = 0.02235$

Although the difference between these measures is much larger than that above, this difference is only slightly larger than the standard error of the estimates (the difference divided by the standard error is 0.01832/0.01658 = 1.10495). The direction of the $f(\overline{G}_i)$ differences would be expected to be as predicted by the simulation but may not be significant.

Averaging over all conditionals except the cost variable gives the following results:

$f(\overline{G}_i|C1) = 0.01475$

$f(\overline{G}_i|C2) = 0.04827$

The difference between these measures is large compared to the standard error of the estimates (the difference divided by the standard error is 0.03353/0.00951 = 3.5258). Consequently, a significant effect would be expected for the cost variable.

These relative relations can be averaged over all but pairs of conditionals. Such measures could indicate the presence of interaction effects of the independent variables. The results of averaging the pairwise conditionals indicate only one interaction of possible significance-- the distribution by cost interaction. The $f(\overline{G}_i)$ measures conditional to these variables are as follows:

$f(\overline{G}_i|S1,C1) = 0.01663$

$f(\overline{G}_i|S1,C2) = 0.06471$

$f(\overline{G}_i|S2,C1) = 0.01287$

$f(\overline{G}_i|S2,C2) = 0.03185$

A graphic representation of this interaction is presented in Figure 4. The difference between the two $f(\overline{G}_i|C1)$ measures is much smaller than the difference between the two $f(\overline{G}_i|C2)$ measures. The differences are 0.00376 and 0.03286, respectively. This would indicate that the distribution variable has a significant effect only when given the C2 cost level. Such a result would explain the larger but not significant effect of the S1 distribution level on the $f(\overline{G}_i|S\_)$ measures.

Other implications which can be derived from these relative relations involve relationships between $f(GP_i)$ and $f(GN_i)$ measures. Two such relationships appear to be of possible significance. Both involve the ratio $f(GP_i)/f(GN_i)$ (i.e., the effect of additional errors relative to the effect of additional correct decisions). The results of the first relationship are as follows:

$f(\overline{GP_i/GN_i}|C1) = 1.20480$

$f(\overline{GP_i/GN_i}|C2) = 1.38337$

The difference between these measures is large compared to the standard error of the estimates (the difference divided by the standard error is 0.17857/0.07621 = 2.34313). Consequently, the GP_i/GN_i ratio is expected to be larger given the C2 cost level than given the C1 cost level.

The results of the second relationship are as follows:

$f(\overline{GP_i/GN_i}|S1,C1) = 1.19908$

$f(\overline{GP_i/GN_i}|S1,C2) = 1.48206$

$f(\overline{GP_i/GN_i}|S2,C1) = 1.21057$

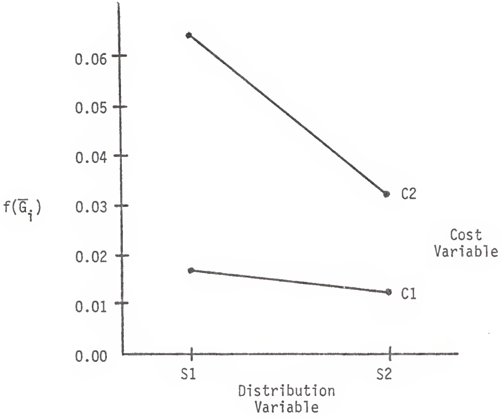


FIGURE 4

SIMULATED COST BY DISTRIBUTION VARIABLE INTERACTION ON f($\overline{G}_i$)

$f(\overline{GP_i/GN_i}|S2,C2) = 1.28465$

The difference between the two $f(\overline{GP_i/GN_i}|S1)$ is much smaller than the difference between the two $f(\overline{GP_i/GN_i}|S2)$. This would indicate the presence of a distribution by cost interaction in which the effect of the cost variable is significant only under the S1 distribution level. A graphical representation of this interaction is presented in Figure 5.

A final implication derived from these relative relations involves the homogeneity of variance for the $f(G_i)$ given the different levels of the cost variable. The variance for the $f(G_i|C1)$ is equal to 5.26×10^{-6} for this simulation, and the variance for the $f(G_i|C2)$ is equal to 6.06×10^{-4} for this simulation. Using the F test for equal variances, F=115.24 (3 and 3 d.f.) which indicates the variances are not equal. Consequently, the variance of $(G_i|C1)$ is expected to be less than the variance of $(G_i|C2)$.

Given the above simulation the effects of the independent variables on the G_i variable can be hypothesized as follows:

H4.1 $\sigma^2(G_i|C1) < \sigma^2(G_i|C2)$.

The G_i of those subjects within the C1 cost level will have significantly smaller variance than will the G_i of those subjects within the C2 cost level.

H4.2a $(\overline{G}_i|C1) < (\overline{G}_i|C2)$.

Those subjects within the C1 cost level will have a significantly smaller mean G_i than will those subjects within the C2 level.

H4.2b $(\overline{G}_i|S2) < (\overline{G}_i|S1)$.

Those subjects within the S2 distribution level will have smaller mean G_i than will those subjects within the S1 level. Significance is not predicted due to the interaction effect with the cost variable.

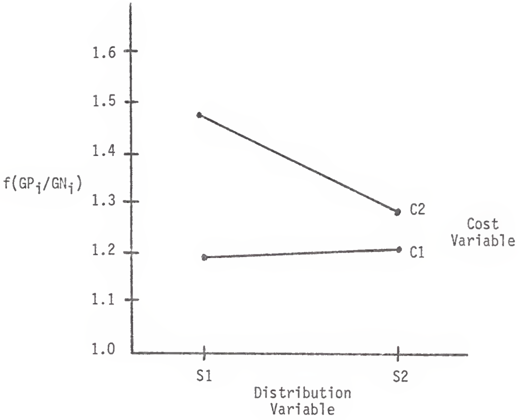


FIGURE 5

SIMULATED COST BY DISTRIBUTION VARIABLE INTERACTION ON $f(GP_i/GN_i)$

H4.2c $(\overline{G}_i | I1) = (\overline{G}_i | I2)$.

The mean G_i of those subjects within the I1 information level and within the I2 information level will be equal.

H4.3 $(\overline{G}_i | S1,C1) - (\overline{G}_i | S2,C1) < (\overline{G}_i | S1,C2) - (\overline{G}_i | S2,C2)$.

There will be a significant interaction of the distribution and cost variables in which the distribution variable will have no significant effect given the C1 cost level but will have a significant effect given the C2 cost level.

H4.4a $(\overline{GP_i/GN_i} | C1) < (\overline{GP_i/GN_i} | C2)$.

Those subjects within the C1 cost level will have a significantly smaller mean GP_i/GN_i than will those subjects within the C2 level.

H4.4 $(\overline{GP_i/GN_i} | C2,S2) - (\overline{GP_i/GN_i} | C1,S2) <$

$(\overline{GP_i/GN_i} | C2,S1) - (\overline{GP_i/GN_i} | C1,S1)$.

There will be a significant interaction of the distribution and cost variables in which the cost variable will have no significant effect given the S2 distribution level but will have a significant effect given the S1 level.

Individual long-run decision efficiency and the training phase

Since performance within the experiment is assumed to be a function of the training adjustment process, it would be expected that the subjects within the PP classification of training adjustment pattern would have a lower average experiment G_i measure than those subjects within the MM classification. Furthermore, the mean expected G_i measure for the mixed classifications (PM and MP) would be expected to fall between those of the non-mixed classifications. The mixed

classifications have one positive adjustment which would improve performance above that of subjects who make only negative adjustments. On the other hand, the mixed classifications have one negative adjustment which would decrease performance below that of subjects who make only positive adjustments.

The following hypotheses predict the effects of the training adjustment pattern on the G_i variable:

H4.5 $(\overline{G}_i|PP) < (\overline{G}_i|MM)$.

Those subjects within the PP classification of training adjustment pattern will have a significantly smaller mean G_i measure than those subjects within the MM classification.

H4.6 $(\overline{G}_i|PP) < (\overline{G}_i|MP) = (\overline{G}_i|PM) < (\overline{G}_i|MM)$.

Those subjects within the mixed classifications of training adjustment pattern will have mean G_is that fall between those of the non-mixed classifications. The mean G_is of the mixed classifications are not expected to be significantly different.

CHAPTER IV

THE EXPERIMENT

Experimental Environment

The decision situation studied within this research was standard cost variance investigation decision making at the operational management level. The experimental setting was the simulated environment of a manufacturing company, and the subjects were requested to assume the role of an operational manager of an assembly department within this environment. The assembly department assembled a single product, a metal folding chair. Subjects were presented with a series of standard cost variance reports for the department and were asked to decide for each report whether the underlying physical process should be investigated to correct an out-of-control situation. Each series of variance reports were cross-sectional in nature: i.e., all reports within a series were assumed to have occurred simultaneously and were independent of each other.

The physical process within the simulated environment was a labor-paced process (Barefield, 1972): i.e., the operating efficiency of the department was determined completely by the labor efficiency of the workers. The labor efficiency standard (stated in terms of time per unit assembled) was based on engineering estimates that allowed for unavoidable labor inefficiencies and reasonable variation in worker

performance (i.e., the standards were currently attainable). The subjects were instructed to accept the labor efficiency standard as fair in terms of control and performance goals.

The physical labor process of the department could be in one of two mutually exclusive states of nature: either in-control or out-of-control. The overall labor process consisted of many individual physical labor operations: the expected aggregate of these procedures was represented by the overall labor efficiency standard. The variance reports, however, included only the aggregate standard and labor efficiency variance. The labor process was defined to be in-control when all of the individual physical procedures were being performed as expected. The labor process was defined to be out-of-control when one or more of these procedures was not being performed as expected.

The task of the subject was to decide whether to investigate each labor efficiency variance for its underlying causes. The purpose of investigation was to facilitate correction of those individual procedures which were not operating as expected. Two assumptions were provided to aid the subject's decision making process. First, if they decided to investigate a variance and the labor process turned out to be out-of-control, the process would be returned to the original in-control state with certainty. Second, if they decided not to investigate a variance and the labor process was out-of-control, the process would remain out-of-control with certainty.

Various costs were associated with the variance investigation decision. These costs depended upon the subject's decision (either investigate or do not investigate) and upon the actual state of the labor process (either in-control or out-of-control). Estimates of these

costs were presented to the subject on the face of each variance report using the following format:

If Your Investigation Decision Is	And If The Assembly Line State Is	Then Your Costs Are: Investigation	Production	Total
Yes	In-control	\$ X	\$ 0.00	\$ X
Yes	Out-of-control	\$ Y	\$ 0.00	\$ Y
No	In-control	\$ 0.00	\$ 0.00	\$ 0.00
No	Out-of-control	\$ 0.00	\$ Z	\$ Z

The letter X represented the estimated investigation cost when the assembly line was in-control. The cost was related to the size of the labor efficiency variance: the more negative (unfavorable) the variance the larger the cost. The letter Y represented the estimated investigation cost when the assembly line was out-of-control. The cost was related to the size of the labor efficiency variance: the more negative (unfavorable) the variance the smaller the cost. Given any particular labor efficiency variance, the investigation cost when out-of-control (Y) was always larger than the investigation cost when in-control (X). This was because the investigation cost included correction costs when the assembly line was out-of-control. The letter Z represented the estimated marginal production cost of operating the next period in the out-of-control state. The cost was constant for all variance reports.

The subjects were told that their immediate supervisor, the product section manager, would evaluate their control performance in terms of their minimization of both investigation and production costs above the expected standard (labeled the total investigation decision cost). A cash bonus was promised to the subjects, the size of the bonus being contingent upon the extent to which they minimized their total investigation decisions cost. The measure of a subject's control performance, labeled $TIDC_{min}$, was determined by summing the total investigation

decision costs incurred by the subject over the series of variance reports and dividing this sum by the sum of the total investigation decision costs incurred by an optimal model over the same series of variance reports. The subject's cash bonus function, constant for all subjects, was inversely related to this measure. As $TIDC_{min}$ approached one, the payoff approached the maximum: as $TIDC_{min}$ became larger than one, the payoff approached the minimum.

Subjects

The subjects were 86 senior year undergraduate and master's level graduate students enrolled in the business college at the University of Florida. The subjects participated in the experiment during a two week period; 47 participated in the first week and 39 participated in the second week. A total of 92 subjects initially volunteered to participate but six subjects failed to complete the experiment. The 86 subjects who completed the experiment consisted of 63 males and 23 females.

Three subject selection criteria were applied: 1) the subject must have completed an intermediate-level managerial accounting course, 2) the subject must have completed an introductory-level statistics course, and 3) the subject must have earned an overall grade point average (GPA) of at least 2.0 on a 4.0 scale.

Subjects initially were contacted within senior level and graduate accounting classes. The contact was made by the experimenter giving a brief oral presentation followed by passing sign-up sheets around each class (a copy of the oral presentation is presented in Appendix B). To motivate volunteering, the presentation focused on the student's professional responsibilities as future accountants and on the monetary

benefits that would accrue to those who volunteered. The subjects were told that they would be given a cash payment for participating in the experiment and that the amount of a subject's payment would depend upon his performance. The minimum payment was set at \$2.00 and the maximum at \$10.00.

Experimental Materials

The experimental materials included a background information booklet, variance investigation decision stimuli, heuristics questionnaire, and motivations questionnaire.

Background Information

A background information booklet (see Appendix C) was designed to provide the subjects with a common experimental environment. The booklet provided the subject with general company information, general product information, general manufacturing process information, and specific assembly department information. The specific assembly department information included information concerning the employees, the physical process, the accounting control system, the subject's task as the operational manager, and the subject's performance evaluation as the operational manager.

Variance Investigation Decisions

Various information constant over all decision trials within a treatment condition was presented on a separate page prior to the start

of the decision trials. The extent of such information depended upon the treatment condition but could include information such as the prior probabilities of both states, the means of both states, the standard deviations of both states, the shape of the distributions of both states, the range of past labor efficiency variances, and the range of past investigation costs. Copies of the prior information pages for two specific treatment conditions are presented in Appendix D.

Each variance investigation decision trial consisted of the presentation of a labor efficiency variance report and a subject's response to two questions. The questions were 1) would you investigate this reported variance, and 2) how strongly do you feel about your decision? During the training phase each decision trial was followed by feedback concerning the actual state of the assembly line and the actual costs incurred for each possible decision given the actual state. Decision trials were presented in booklets of 33 trials (each trial included the report with questions followed by the feedback). Within the experimental phase decision trials were presented in booklets of 50 trials (each trial included only the report with questions). In both the training and the experimental phases, answer sheets were provided for the subject to record his responses.

An example of a labor efficiency variance report with the set of questions is presented in Figure 6. The format of the report and questions was constant for all treatment conditions: the only variation related to the distribution of the actual minutes incurred per chair and the labor efficiency variance, and to the magnitude and structure of the costs of investigation.

AMSECO
Metal Folding Chair Assembly Department
Labor Efficiency Variance Report For Job 5247

Standard Minutes Allowed Per Chair	Actual Minutes Incurred Per Chair	Labor Efficiency Variance Per Chair	Total Chairs Produced
36.0	44.0	-8.0	200

The Costs Associated With Investigation Are:

If Your Investigation Decision Is	And If The Assembly Line State Is	Then Your Costs Are Investigation	Production	Total
Yes	In-Control	$ 28.33	$ 0.00	$ 28.33
Yes	Out-Of-Control	$ 90.00	$ 0.00	$ 90.00
No	In-Control	$ 0.00	$ 0.00	$ 0.00
No	Ou-Of-Control	$ 0.00	$ 175.00	$ 175.00

###

Please answer the following questions placing your answers on the answer sheet:

A. Would you investigate this reported variance /circle the appropriate response on the answer sheet/

NO YES

B. How strongly do you feel about your decision /select a number between 0 and 100 which indicates the strength of your feeling and place this number on the answer sheet/

```
 0   10   20   30   40   50   60   70   80   90   100
 *    *    *    *    *    *    *    *    *    *    *
 **************************************************
 *    *    *    *    *    *    *    *    *    *    *
 *                        *                        *
Uncertain            Reasonably                Almost
                       Certain                 Certain
```

FIGURE 6

VARIANCE INVESTIGATION DECISION TRIAL

Elicitation of Heuristics

The elicitation of each subject's heuristics was accomplished using a predominately open-ended questionnaire (see Appendix E). The objectives of this questionnaire were 1) to determine the strategy the subject used in answering the variance investigation questions within the experimental phase, 2) to determine, where appropriate, the exact values of any numerical rules used by the subject, 3) to determine whether the subject thought he used his strategy consistently within the experimental phase, 4) to determine the method or approach used by the subject in forming his strategy within the training phase, and 5) to determine the subjective importance attached to each information item presented to the subject.

Elicitation of Subject Motivations

Subject motivations were elicited using a motivation questionnaire (see Appendix F) developed by Snowball and Brown (1977). The questionnaire is a ten item Likert-type scale which has submeasures for both intrinsic and extrinsic motivation.

Experimental Procedures

Experimental procedures included assignment of subjects to treatment conditions, adminstration of a training phase, administration of an experimental phase, and final debriefing.

Assignment of Subjects to Treatment Conditions

Since each of the 86 subjects was assigned to one of eight groups, randomization per se can not be relied upon to control for individual attribute differences between groups. An alternative is to block the randomization process on individual attribute dimensions assumed to significantly affect the subject's information processing within the task required by the experiment.

The literature relating to individual attributes has not produced conclusive results concerning individual attributes effect on decision processes. The most comprehensive study is that of Taylor and Dunnette (1974) who analyzed the effect of 16 decision maker attributes upon eight measures of predecisional, decision-point, and post decisional processes within a personnel decision simulation experiment. Of considerable interest is that the relevant decision maker attributes accounted for a generally small portion of the total decision variance within the various processes (the range was from 8 percent to 33 percent). The decision maker attribute with the greatest predictive capacity was intelligence. In two of the predecisional processes (diagonosticity and information processing rate) and in two of the decision-point and post decisional processes (information retention and decision accuracy), intelligence accounted for from one-half to almost all of the variance explained by individual characteristics.

In the present study, the randomization process of assigning subjects to treatment conditions was blocked on individual intelligence. Ideally, individual intelligence should be measured using some validated instrument (e.g., the Wesman Personnel Classification Test or the

Wechsler Adult Intelligence Scale). Due to resource limitations, however, subject grade point average (GPA) was used as a surrogate for such a measure. A median GPA was identified, and those subjects with a GPA above the median were categorized as above average intelligence and those subjects with a GPA below the median were categorized as average intelligence. Each subject within an intelligence category then was assigned randomly to one of the treatment conditions with the restriction that each intelligence group contributed an equal number of subjects to each condition.[1] Upon assignment to a treatment condition each subject received the background information booklet.

Training Phase

Each subject received training within the treatment condition to which he was assigned. Training was conducted in groups of two subjects within a 50 minute session administered by either the experimenter or by an experimental assistant.[2] Subjects were assigned randomly to the experimental assistants subject to two restrictions. The restrictions were that the experimental assistant was not currently the subject's teacher for an academic course and that the subject's available time coincided with that of the experimental assistant. Training of all

[1]The assignment process involved two procedures. First, the assignment to the cost variable levels was by the week in which the subject participated in the experiment. Those subjects who participated during the first week were assigned to the C1 cost level, and those subjects who participated during the second week were assigned to the C2 cost level. Second, the assignment to the information variable and the distribution variable levels was by random selection based upon a random number table.

[2]The experimental assistants were not paid. The author believes, however, that this is an exception to the aphorism that price reflects value.

subjects (within each week) was completed over two contiguous days. The training phase consisted of 99 decision trials with feedback. The experimental materials used in the training phase were similar to those used in the experimental phase. The decision trials with feedback were presented in three booklets of 33 trials and the subject was provided an answer sheet on which to record his responses. Additional performance feedback was given at the completion of each book of 33 decision trials. This performance feedback was the subjects's $TIDC_{min}$ for that particular book.

Experimental Phase

The experimental session lasted one hour and was administered by the experimenter. The experimental phase (within each week) was completed over two contiguous days immediately following the training phase.

The experimental session consisted of three parts. The first part was the presentation of 100 decision trials. The decision trials were presented in two booklets of 50 trials each and the subject recorded his responses on a separate answer sheet. The subjects were allowed twenty minutes to complete the 100 decision trials. The second part of the experimental phase was the elicitation of the subject's heuristics. This elicitation was accomplished using the open-ended questionnaire (see Appendix E). The third part of the experimental phase was the administration of the motivation questionnaire (see Appendix F).

Final Debriefing

Each subject's final performance measure ($TIDC_{min}$) for the variance investigation decisions part of the experimental phase was presented individually at a later date. At this time his cash payment was determined, he was debriefed as to the purpose of the experiment, and any questions were answered. Additional data were collected from those subjects not responding completely to the heuristic elicitation questionnaire.

CHAPTER V

ANALYSES AND RESULTS

Summary of Results

A summary of the analyses and results contained in this chapter is presented in Table 4. The objective of this summary is to provide a brief statement of each hypothesis together with the results of analyses for that hypothesis. Such a summary will facilitate the presentation of the analyses and results and will serve as a reference for the discussion and conclusions contained in the next chapter.

General Method of Analysis

Although several methods of analysis are employed, the most prevalent method is analysis of variance using the model comparison procedure (Appelbaum and Cramer, 1974; Lewis and Keren, 1977). This method of analysis is employed due to the nonorthogonality of the data structure. The problem of nonorthogonality arises in this instance as a result of non-equal cell frequencies.

The model comparison procedure involves fitting a linear model allowing for certain effects and then comparing the obtained fit to that of a linear model which omits one or more of the effects. The objective is to find the simplest model that adequately fits the data. The procedure begins with the complete or full model (which allows for

TABLE 4

SUMMARY OF ANALYSES AND RESULTS

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
1.1a $(\overline{TDV_i}\mid S1)=38.5$	Two-tailed Z test	$Z=0.9912$ (n.s.)	The mean initial decision anchor of those subjects within the S1 distribution level was not significantly different from 38.5
1.1b $(\overline{TDV_i}\mid S2)=40.5$	Two-tailed Z test	$Z=1.5681$ ($p<.10$)	The mean initial decision anchor of those subjects within the S2 distribution level was significantly less than 40.5
1.2a $(\overline{TDV_i}\mid I1)=(\overline{TDV_i}\mid I2)$	Model comparison Two-tailed Z test	$F=1.0944$ (n.s.) $Z=0.7007$ (n.s.)	The mean initial decision anchor of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.
1.2b $(\overline{TDV_i}\mid C1)=(\overline{TDV_i}\mid C2)$	Model comparison Two-tailed Z test	$F=3.3931$ ($p<.10$) $Z=1.4362$ ($p<.10$)	The mean initial decision anchor of those subjects within the C1 cost level was significantly smaller than that of those subjects within the C2 cost level.
1.3a $(\overline{RA_i}\mid I1)=(\overline{RA_i}\mid I2)$	Model comparison Two-tailed Z test	$F=0.0903$ (n.s.) $Z=0.4432$ (n.s.)	The mean relative decision anchor adjustment of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
1.3b $(\overline{RA}_i \mid S1)=(\overline{RA}_i \mid S2)$	Model comparison	$F=1.7308$ (n.s.)	The mean relative decision anchor adjustment of those subjects within the S1 distribution level was not significantly different from that of those subjects within the S2 distribution level.
	Two-tailed Z test	$Z=1.3054$ (n.s.)	
1.3c $(\overline{RA}_i \mid C1)=(\overline{RA}_i \mid C2)$	Model comparison	$F=0.1735$ (n.s.)	The mean relative decision anchor adjustment of those subjects within the C1 cost level was not significantly different from that of those subjects within the C2 cost level.
	Two-tailed Z test	$Z=0.4865$ (n.s.)	
2.1a $(\overline{d}'_i \mid S1)<(\overline{d}'_i \mid S2)$	Model comparison	$F=46.0985$ ($p<.01$)	The mean decision model sensitivity of those subjects within the S1 distribution level was significantly smaller than that of those subjects within the S2 distribution level.
	One-tailed Z test	$Z=6.1144$ ($p<.01$)	
2.1b $(\overline{d}'_i \mid I1)=(\overline{d}'_i \mid I2)$	Model comparison	$F=0.5883$ (n.s.)	The mean decision model sensitivity of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.
	Two-tailed Z test	$Z=0.4588$ (n.s.)	
2.1c $(\overline{d}'_i \mid C1)=(\overline{d}'_i \mid C2)$	Model comparison	$F=0.2638$ (n.s.)	The mean decision model sensitivity of those subjects within the C1 cost level was not significantly different from that of those subjects within the C2 cost level.
	Two-tailed Z test	$Z=0.3167$ (n.s.)	

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
2.2a $(\overline{DNA_i}\mid I1)=(\overline{DNA_i}\mid I2)$	Model comparison Two-tailed Z test	$F=0.0066$ (n.s.) $Z=0.0010$ (n.s.)	The mean adjusted relative decision model sensitivity of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.
2.2b $(\overline{DNA_i}\mid S1)=(\overline{DNA_i}\mid S2)$	Model comparison Two-tailed Z test	$F=0.8368$ (n.s.) $Z=0.4662$ (n.s.)	The mean adjusted relative decision model sensitivity of those subjects within the S1 distribution level was not significantly different from that of those subjects within the S2 distribution level.
2.2c $(\overline{DNA_i}\mid C1)=(\overline{DNA_i}\mid C2)$	Model comparison Two-tailed Z test	$F=15.3114$ $(p<.01)$ $Z=3.6362$ $(p<.01)$	The mean adjusted relative decision model sensitivity of those subjects within the C1 cost level was significantly larger than that of those subjects within the C2 cost level.
2.3a $(\overline{DNA_i-DN_i}\mid S1)$ < $(\overline{DNA_i DN_i}\mid S2)$	Model comparison One-tailed Z test	$F=6.0130$ $(p<.05)$ $Z=2.2737$ $(p<.05)$	The mean multiple decision anchor effect on relative decision model sensitivity of those subjects within the S1 distribution was significantly larger than that of those subjects within the S2 distribution level.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
2.3b $(\overline{DNA_i - DN_i} \mid C1) <$ $(\overline{DNA_i - DN_i} \mid C2)$	Model comparison One-tailed Z test	F=0.6618 (n.s.) Z=0.8642 (n.s.)	The mean multiple decision anchor effect on relative decision model sensitivity of those subjects within the C1 cost level was not significantly different from that of those subjects within the C2 cost level.
3.1a $(\overline{BNA_i} \mid I1) = (\overline{BNA_i} \mid I2)$	Model comparison Two-tailed Z test	F=2.6738 (n.s.) Z=0.7891 (n.s.)	The mean adjusted relative decision criteria of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.
3.1b $(\overline{BNA_i} \mid S1) = (\overline{BNA_i} \mid S2)$	Model comparison Two-tailed Z test	F=1.9398 (n.s.) Z=0.7048 (n.s.)	The mean adjusted relative decision criteria of those subjects within the S1 distribution level was not significantly different from that of those subjects within the S2 distribution level.
3.1c $(\overline{BNA_i} \mid C1) > (\overline{BNA_i} \mid C2)$	Model comparison One-tailed Z test	F=107.4386 (p<.01) Z=10.6306 (p<.01)	The mean adjusted relative decision criteria of those subjects within the C1 cost level was significantly larger than that of those subjects within the C2 cost level.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
3.2 $\sigma^2(BNA_i\|C1) <$ $\sigma^2(BNA_i\|C2)$	F test of equal variances	$F=9.36$ $(p<.01)$	The adjusted relative decision criteria variance of those subjects within the C1 cost level was significantly larger than that of those subjects within the C2 cost level.
3.3a $(\overline{BNC_i}\|I1)=(\overline{BNC_i}\|I2)$	Model comparison Two-tailed Z test	$F=0.9075$ (n.s.) $Z=0.6802$ (n.s.)	The mean decision criteria conservatism of those subjects within the reduced information level was not significantly different from that of those subjects within the expanded information level.
3.3b $(\overline{BNC_i}\|S1)=(\overline{BNC_i}\|S2)$	Model comparison Two-tailed Z test	$F=0.3377$ (n.s.) $Z=0.3295$ (n.s.)	The mean decision criteria conservatism of those subjects within the S1 distribution level was not significantly different from that of those subjects within the S2 distribution level.
3.3c $(\overline{BNC_i}\|C1)<(\overline{BNC_i}\|C2)$	Model comparison One-tailed Z test	$F=6.6104$ $(p<.05)$ $Z=2.5598$ $(p<.05)$	The mean decision criteria conservatism of those subjects within the C1 cost level was significantly larger than that of those subjects within the C2 cost level.
3.4a $(\overline{BNA_i-BN_i}\|S1) <$ $(\overline{BNA_i-BN_i}\|S2)$	Model comparison One-tailed Z test	$F=0.0924$ (n.s.) $Z=0.3892$ (n.s.)	The mean multiple decision anchor effect on relative decision criteria of those subjects within the S1 distribution level was not significantly different from that of those subjects within the S2 distribution level.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
3.4b $(\overline{BNA_i - BN_i} \mid C1) <$ $(\overline{BNA_i - BN_i} \mid C2)$	Model comparison One-tailed Z test	$F=11.4812$ $(p<.01)$ $Z=3.7090$ $(p<.01)$	The mean multiple decision anchor effect on relative decision criteria of those subjects within the C1 cost level was significantly larger than that of those subjects within the C2 cost level.
4.1 $\sigma^2(G_i \mid C1) < \sigma^2(G_i \mid C2)$	F test of equal variances	$F=2.43$ $(p<.01)$	The relative net decision costs variance of those subjects within the C1 cost level was significantly smaller than that of those subjects within the C2 cost level.
4.2a $(\overline{G}_i \mid C1) < (\overline{G}_i \mid C2)$	Sources F value One-tailed Z test	$F=2.56$ (n.s.) $Z=2.442$ $(p<.01)$	The mean relative net decision costs of those subjects within the C2 cost level was larger than that of those subjects within the C1 cost level.
4.2b $(\overline{G}_i \mid S2) < (\overline{G}_i \mid S1)$	Sources F value One-tailed Z test	$F=0.51$ (n.s.) $Z=1.7452$ $(p<.05)$	The mean relative net decision costs of those subjects within the S1 distribution level was larger than that of those subjects within the S2 distribution level.
4.2c $(\overline{G}_i \mid I1) = (\overline{G}_i \mid I2)$	Model comparison Two-tailed Z test	$F=1.0488$ (n.s.) $Z=0.4528$ (n.s.)	The mean relative net decision costs of those subjects within the reduced information level was not significantly different than that of those subjects within the expanded information level.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
4.3 $[(\overline{G}_i\|S1,C1)-(\overline{G}_i\|S2,C1)]$ $<[(\overline{G}_i\|S1,C2)-(\overline{G}_i\|S2,C2)]$	Model comparison Duncan's multiple range test	$F=7.7124$ $(p<.01)$ $(\alpha=.01)$	There was a significant cost by distribution interaction on the relative net decision costs in which the C2 cost level had a greater effect than the C1 cost level while the distribution levels had little effect.
4.4a $(\overline{GP_i/GN_i}\|C1) <$ $(\overline{GP_i/GN_i}\|C2)$	Sources F value One-tailed Z test	$F=0.35$ (n.s.) $Z=2.0198$ $(p<.01)$	The mean relative additional decision costs and relative additional decision savings ratio of those subjects within the C2 cost level was larger than that of those subjects within the C1 cost level.
4.4b $[(\overline{GP_i/GN_i}\|C2,S2)-$ $(\overline{GP_i/GN_i}\|C1,S2)]$ $<[(\overline{GP_i/GN_i}\|C2,S1)-$ $(\overline{GP_i/GN_i}\|C1,S1)]$	Model comparison Duncan's multiple range test	$F=8.7438$ $(p<.01)$ $(\alpha=.01)$	There was a significant cost by distribution interaction on the relative additional decision costs and relative additional decision savings ratio in which the cost levels had a significant effect only when given the S1 distribution level.
4.5 $(\overline{G}_i\|PP)<(\overline{G}_i\|MM)$	One-tailed t test	$t=1.303$ $(p<.10)$	The mean relative net decision costs of those subjects within the constantly decreasing training session performances category was significantly smaller than that of those subjects within the constantly increasing training session performances category.

TABLE 4-- Continued

Hypotheses	Analysis Method(s)	Test Statistic(s)	Results
4.6 $(\overline{G}_i \mid PP) < (\overline{G}_i \mid MP) = (\overline{G}_i \mid PM) < (\overline{G}_i \mid MM)$	-	-	The mean relative net decision costs of those subjects within the mixed training session performances categories were less than that of those subjects within the constantly increasing training session performances category and greater than that of those subjects within the constantly decreasing training session performances category.

all effects) and eliminates effects starting with the highest order interactions. The model comparisons utilize the general linear model theory (the method of least squares) as described by Scheffé (1959) and the F test as described by Lewis and Keren (1977) is used to test the fit of the various models. Defining two models as Ω and ω, the F test is:

$$F = \frac{d.f.(\Omega)}{d.f.(\omega-\Omega)} \cdot \frac{SSe(\omega) - SSe(\Omega)}{SSe(\Omega)}$$

where ω is the more restricted model and the degrees of freedom associated with the numerator and the denominator of the F statistic are $d.f.(\omega-\Omega)$ and $d.f.(\Omega)$, respectively.

Given a dependent variable, the model comparison procedure is used to find the simplest model which adequately fits the data. After the simplest (or reduced) model is found the sources of this model are presented with their corresponding F values. These source F values are the same as model comparison F tests where the comparison models are the reduced model and the reduced model without the corresponding source. Within this research the source F values are also the same as the Type IV sum of squares (Barr et al., 1976).

Unless otherwise specified, the α levels for the rejection of the null hypothesis are $p<.10$ for main effects and $p<.05$ for interactions. The selection of these α values is largely arbitrary: the values reflect the preliminary nature of this research. Also, unless otherwise specified, all 2-way interactions are tested against the without 3-way interaction model, employing the assumption that the 3-way interaction effect is equal to zero within the subject population. All the individual attributes are retained in each model, employing the assumption that

these effects are not necessarily equal to zero within the subject population.

The parameters used by the various models as independent variables are defined as follows:

μ = the overall mean of the dependent variable,

α_j= the effect of level j of the information variable,

β_k= the effect of level k of the distribution variable,

γ_l= the effect of level l of the cost variable,

$\alpha\beta_{jk}$, $\alpha\gamma_{jl}$, $\beta\gamma_{kl}$, $\alpha\beta\gamma_{jkl}$= the various interactions of the above three variables,

ψ_i= the effect of individual i's DN measure,

ξ_i= the effect of individual i's intrinsic motivation measure,

τ_i= the effect of individual i's extrinsic (non-monetary) motivation measure,

λ_i= the effect of individual i's extrinsic (monetary) motivation measure, and

δ_i= the effect of individual i's GPA.

Training Phase Analyses and Results

The following sections report the analyses and results of the training phase. The sections include the initial decision anchors and the decision anchor adjustment.

Initial Decision Anchors

Hypotheses 1.1 and 1.2 relate to an assumption made in the conceptual development and simulation: i.e., that subjects would use a point of central tendency (between the means of the appropriate states

of nature) as their initial decision anchor. The simulation arbitrarily employed the geometric intersection of the appropriate state distribution curves as the expected initial decision anchor. These expected points are conditional upon the distribution variable: i.e., the intersection point is 38.25 actual minutes incurred given the S1 distribution level and is 40.5 actual minutes incurred given the S2 distribution level. The cutoff points employed within the first training session (TDV_is) were used as an estimate of the subjects' initial decision anchors.

The method of analysis was the model comparison procedure where the dependent variable is the TDV_i measure and the independent variables are the three situation variables (information, distribution, and cost) with their interactions, and the GPA variable. The full TDV_i model is:

$$TDV_i = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \delta_i$$

The model comparison procedure results for this analysis are presented in Table 5, and the F values associated with the sources of the reduced model are presented in Table 6. The results indicate that the reduced model contains the distribution variable and the cost variable main effects. The distribution variable main effect is significant at the $p<.01$ level and the cost variable main effect is significant at the $p<.10$ level. The means, variances, and sample sizes of the TDV_i measure given the levels of these two independent variables are included in Table 6. Using the F test of equal variances, the variances between the levels of the distribution variable differ significantly ($F=2.82$, $p<.01$), with the S2 level having the greater variance. The variances between the levels of the cost variable do not differ significantly ($F=1.12$, n.s.). Using the Z test of equal means, the means of the levels

TABLE 5

MODEL COMPARISON PROCEDURE RESULTS FOR THE TDV_i DEPENDENT VARIABLE

Model	SSe	d.f.(F)	F
Full[d]	91.6549	8,77	8.19[a]
Without 3-way interaction	93.1248	1,77	1.23
Without distribution x cost interaction	93.1426	1,78	0.01
Without information x distribution interaction	93.1463	1,78	0.02
Without information x cost interaction	93.7287	1,78	0.51
Without information[e]	95.0374	1,81	1.09
Without distribution[e]	164.6998	1,81	61.27[a]
Without cost[e]	97.6986	1,81	3.39[c]

[a] $p<.01$

[b] $p<.05$

[c] $p<.10$

[d] The F value associated with the full model is the test of the full model and not a model comparison test.

[e] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 6

PARAMETER VALUES ASSOCIATED WITH THE REDUCED TDV_i MODEL

F Values Associated With the Sources of the Reduced Model

Source	d.f.	F
Distribution	1,81	60.84[a]
Cost	1,81	3.59[b]
GPA	1,81	0.02

Means and Variances Associated With the Significant Sources

Variable Level	N	Mean	Variance
S1	44	38.368	0.62548
S2	42	40.179	1.76465
C1	47	39.053	1.86776
C2	39	39.492	2.09599

[a] $p<.01$

[b] $p<.10$

of the distribution variable differ significantly ($Z=7.6346$, $p<.01$ two-tailed), with the S2 level having the larger mean. Differences in the means of the levels of the cost variable are also significant ($Z=1.4362$, $p<.10$ two-tailed), with the C2 level having the larger mean.

Hypothesis 1.1a predicted that $(\overline{TDV}_i|S1)$ would not differ significantly from 38.25 actual minutes incurred. A single-sample Z test was employed to test this hypothesis, and the difference was found to be not significant ($Z=0.9912$, n.s. two-tailed). Hypothesis 1.1b predicted that $(\overline{TDV}_i|S2)$ would not differ significantly from 40.5 actual minutes incurred. A single-sample Z test indicated that the difference was significant ($Z=1.5681$, $p<.10$ two-tailed). Hypothesis 1.2a predicted that $(\overline{TDV}_i|I1)$ would not differ significantly from $(\overline{TDV}_i|I2)$. The Z test used to test this hypothesis indicated no significant difference ($Z=0.7007$, n.s. two-tailed). Hypothesis 1.2b predicted that $(\overline{TDV}_i|C1)$ would not differ significantly from $(\overline{TDV}_i|C2)$. This hypothesis was tested by the above model comparison procedure and related Z test, and the results indicated that the difference was significant ($p<.10$).

Decision Anchor Adjustment

Hypothesis 1.3 relates to an assumption made in the training phase simulation: i.e., that subjects would have equal relative decision anchor adjustment between the levels of the various experiment conditions. The simulation arbitrarily used an adjustment of one-half the linear distance between the appropriate expected initial decision anchor and the appropriate optimal model decision cutoff value.

The method of analysis was the model comparison procedure where the dependent variable is the RA_i measure and the independent variables

are the three situation variables (with their interactions) and the GPA_i variable. The full RA_i model is:

$$RA_i = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \delta_i$$

The model comparison procedure results for this analysis are presented in Table 7. The results indicate that the reduced model containes only the μ parameter: i.e., none of the situation variables had a significant effect on an individual's relative decision anchor adjustment. Using the F test of equal variances, the variances between the levels of the distribution variable and between the levels of the cost variable were found to differ significantly ($F=5.22$, $p<.01$; $F=6.23$, $p<.01$). The S2 distribution level and the C1 cost level had the greater variances.

Hypothesis 1.3a predicted that $(\overline{RA_i}|I1)$ would not differ significantly from $(\overline{RA_i}|I2)$. A Z test indicated that the difference was not significant ($Z=0.4432$, n.s. two-tailed). Hypothesis 1.3b predicted that $(\overline{RA_i}|S1)$ would not differ significantly from $(\overline{RA_i}|S2)$. The application of the Z test revealed no significant difference ($Z=1.3052$, n.s. two-tailed). Hypothesis 1.3c predicted that $(\overline{RA_i}|C1)$ would not differ significantly from $(\overline{RA_i}|C2)$. A Z test was employed to test this hypothesis: again, the difference was found to be not significant ($Z=0.4865$, n.s. two-tailed).

Table 8 presents the actual patterns of the $\overline{TDV_i}$ and $\overline{EDV_i}$ measures given the various levels of the distribution and cost variables. Given that the TDV_i measures have incorporated some initial adjustment (during the first training session), the expected $\overline{TDV_i}$ and $\overline{EDV_i}$ patterns are 1) $(\overline{EDV_i}|C1,S1) < (\overline{TDV_i}|C1,S1) < 38.25 < (\overline{TDV_i}|C2,S1) < (\overline{EDV_i}|C2,S1)$, and 2) $(\overline{EDV_i}|C1,S2) < (\overline{TDV_i}|C1,S2) < 40.5 < (\overline{TDV_i}|C2,S2) < (\overline{EDV_i}|C2,S2)$.

TABLE 7

MODEL COMPARISON PROCEDURE RESULTS FOR THE RA_i DEPENDENT VARIABLE

Model	SSe	d.f.(F)	F
Full[a]	67.8716	8,73	0.58
Without 3-way interaction	67.8852	1,73	0.01
Without distribution x cost interaction	67.8852	1,74	0.00
Without information x distribution interaction	67.8889	1,74	0.00
Without information x cost interaction	68.2633	1,74	0.41
Without information[b]	68.3470	1,77	0.09
Without distribution[b]	69.8016	1,77	1.73
Without cost[b]	68.4208	1,77	0.17

[a]The F value associated with the full model is the test of the full model and not a model comparison test.

[b]The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 8

OBSERVED MEAN EDV_iS AND TDV_iS GIVEN THE VARIOUS LEVELS OF THE DISTRIBUTION AND COST VARIABLES

Distribution Variable	C1 Cost Variable Level		Expected Initial Decision Anchor	C2 Cost Variable Level	
	$\overline{EDV}$	$\overline{TDV}$		$\overline{TDV}$	$\overline{EDV}$
S1	37.83	38.16	38.25	38.62	39.01
S2	39.62	39.98	40.50	40.41	42.43

The expected pattern given the S1 distribution level was obtained. However, the expected pattern given the S2 distribution level was not consistent with respect to the expected initial decision anchor (40.5).

Individual Decision Model Sensitivity

The following sections report the analyses and results of the individual decision model sensitivity variables. The variables include the d_i' dependent variable, the relative decision model sensitivity, and the relationships between intrinsic motivation and decision model sensitivity.

The d_i' Dependent Variable

Hypothesis 2.1 relates to the fit of the subjects' responses to the TSD model. The dependent variable d_i' should have little relation with the information and cost situation variables, but should have a relation with the distribution variable. The relation with the distribution variable is derived from the optimal model decision sensitivity measure, d_k'. Within the S1 level of the distribution variable the theoretical value of d_k' is 1.5, and within the S1 level of the distribution variable the theoretical value of d_k' is 1.8.

The method of analysis was the model comparison procedure where the dependent variable is the d_i' measure and the independent variables are the three situation variables (with their interactions), the three motivation factors, and the GPA_i variable. The full d_i' model is:

$$d_i' = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \xi_i + \tau_i + \lambda_i + \delta_i$$

The model comparison procedure results for this analysis are presented in Table 9 and the F values associated with the sources of the reduced model are presented in Table 10. The results indicate that the d_i' reduced model contains only the distribution variable and the intrinsic motivation factor. Both of these parameters are significant at the p<.01 level. The means, variances, and sample sizes of the d_i' measure given the levels of the distribution variable are included in Table 10. Applying the F test of equal variances, the variances between the levels of this variable do not differ significantly (F=1.27, n.s.). However, the Z test of equal means indicates that the means of the levels of this variable differ significantly (Z=6.1144, p<.01 two-tailed).

Hypothesis 2.1a predicted that $(\overline{d_i'}\,|S1)$ would be significantly less than $(\overline{d_i'}\,|S2)$. This hypothesis was tested by the model comparison procedure and Z test presented above, and the difference was found to be significant (p<.01), with the S1 level having the smaller mean. Hypothesis 2.1b predicted that $(\overline{d_i'}\,|I1)$ would not differ significantly from $(\overline{d_i'}\,|I2)$. This hypothesis was tested using a Z test, and the difference was found to be not significant (Z=0.4588, n.s. two-tailed). Hypothesis 2.1c predicted that $(\overline{d_i'}\,|C1)$ would not differ significantly from $(\overline{d_i'}\,|C2)$. A Z test indicated that the difference was not significant (Z=0.3167, n.s. two-tailed).

Relative Decision Model Sensitivity

Hypotheses 2.2 and 2.3 relate to the adjusted relative deviation of the individual's decision model sensitivity from the optimal model sensitivity. The adjustment is concerned with the elimination of the

TABLE 9

MODEL COMPARISON PROCEDURE RESULTS FOR THE d_i' DEPENDENT VARIABLE

Model	SSe	d.f.(F)	F
Full[b]	5.8767	11,74	4.66[a]
Without 3-way interaction	5.8926	1,74	0.20
Without distribution x cost interaction	5.9032	1,75	0.13
Without information x distribution interaction	5.8947	1,75	0.03
Without information x cost interaction	5.8969	1,75	0.05
Without information[c]	5.9950	1,78	0.59
Without distribution[c]	9.4035	1,78	46.10[a]
Without cost[c]	5.9304	1,78	0.26

[a] $p<.01$

[b] The F value associated with the full model is the test of the full model and not a model comparison test.

[c] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 10

PARAMETER VALUES ASSOCIATED WITH THE REDUCED d_i' MODEL

F Values Associated With the Sources of the Reduced d' Model

Source	d.f.	F
Distribution	1,80	46.52[a]
Intrinsic motivation	1,80	10.33[a]
Extrinsic (non-monetary) motivation	1,80	1.80
Extrinsic (monetary) motivation	1,80	0.06
GPA	1,80	0.20

Means and Variances Associated With the Significant Sources

Variable Level	N	Mean	Variance
S1	44	1.2325	0.09165
S2	42	1.6093	0.07200

[a] $p<.01$

effects of multiple cutoff values on individual decision model sensitivity. Assuming random subject assignment to experimental situations, the DN_i and DNA_i variables should be independent of the effects of the d' absolute magnitude differences (within the distribution variable). The remaining effects are 1) the relative variable response range within the DNA_i measure, and 2) the relative variable response range and multiple cutoff value usage within the DN_i measure.

The methods of analysis were the model comparison procedures where the dependent variables are the DN_i, DNA_i, and DNA_i-DN_i measures. The independent variables are the three situation variables (with their interactions), the three motivation factors, and the GPA_i variable. The three full models are

$$\left.\begin{array}{l} DN_i \\ DNA_i \\ DNA_i-DN_i \end{array}\right| \begin{array}{l} \\ = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \xi_i \\ \quad + \tau_i + \lambda_i + \delta_i \end{array}$$

The three model comparison procedure results are presented in Table 11 and the F values associated with the sources of the reduced models are presented in Table 12. The results indicate that the reduced DN_i model contains the distribution variable, the cost variable, and the intrinsic motivation factor. Both the distribution variable main effect and the motivation factor are significant at the $p<.01$ level, and the cost variable is significant at the $p<.05$ level. The reduced DNA_i model contains the cost variable and the intrinsic motivation factor. The cost variable main effect is significant at the $p<.01$ level and the motivation factor is significant at the $p<.10$ level. The reduced DNA_i-DN_i model contains the distribution variable and the intrinsic motivation factor. The distribution variable main effect is

TABLE 11

MODEL COMPARISON PROCEDURE RESULTS FOR THE DN_i, DNA_i, AND DNA_i-DN_i DEPENDENT VARIABLES

Model	DN_i			DNA_i			DNA_i-DN_i		
	SSe	d.f.(F)	F	SSe	d.f.(F)	F	SSe	d.f.(F)	F
Full[d]	2.1852	11,74	4.66[a]	1.1753	11,74	2.03[b]	1.4200	11,74	0.97
Without 3-way interaction	2.2031	1,74	0.61	1.1758	1,74	0.03	1.4327	1,74	0.66
Without distribution x cost interaction	2.2236	1,75	0.70	1.2105	1,75	2.22	1.4345	1,75	0.10
Without information x distribution interaction	2.2032	1,75	0.00	1.1783	1,75	0.16	1.4343	1,75	0.09
Without information x cost interaction	2.2123	1,75	0.31	1.1758	1,75	0.00	1.4412	1,75	0.45
Without information[e]	2.2324	1,78	0.00	1.2140	1,78	0.01	1.4453	1,78	0.01
Without distribution[e]	2.4330	1,78	7.01[a]	1.2269	1,78	0.84	1.5566	1,78	6.01[b]
Without cost[e]	2.3748	1,78	4.98[b]	1.4522	1,78	15.31[a]	1.4575	1,78	0.66

[a] $p<.01$ [b] $p<.05$ [c] $p<.10$

[d] The F value associated with the full model is the test of the full model and not a model comparison test.

[e] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 12

PARAMETER VALUES ASSOCIATED WITH THE REDUCED DN_i, DNA_i, AND DNA_i-DN_i MODELS

F Values Associated With the Sources of the Reduced Models

Source	DN_i		DNA_i		DNA_i-DN_i	
	d.f.	F	d.f.	F	d.f.	F
Distribution	1,79	7.10^a			1,80	6.17^b
Cost	1,79	5.05^b	1,80	15.52^a		
Intrinsic motivation	1,79	8.64^a	1,80	3.55^c	1,80	3.59^c
Extrinsic (non-monetary) motivation	1,79	1.68	1,80	1.38	1,80	0.24
Extrinsic (monetary) motivation	1,79	0.04	1,80	0.07	1,80	0.01
GPA	1,79	0.02	1,80	0.14	1,80	0.27

Means and Variances Associated With the Significant Variables

Variable Level	DN_i			DNA_i			DNA_i-DN_i		
	N	Mean	Variance	N	Mean	Variance	N	Mean	Variance
S1	44	0.8052	0.0391	44	0.9193	0.0183	44	0.1141	0.0249
S2	42	0.8845	0.0240	42	0.9329	0.0180	42	0.0484	0.0113
C1	47	0.8789	0.0276	47	0.9726	0.0091	47	0.0938	0.0197
C2	39	0.8017	0.0369	39	0.8696	0.0234	39	0.0679	0.0185

$^a p<.01$ $^b p<.05$ $^c p<.10$

significant at the $p<.05$ level, and the motivation factor is significant at the $p<.10$ level.

Means, variances, and sample sizes of the three dependent variables given the levels of the significant situation variables are included in Table 12. Using the F test of equal variances, the following variances were found to differ significantly: 1) within the DN_i variable between the levels of the distribution variable ($F=1.63$, $p<.10$), 2) within the DNA_i variable between the levels of the cost variable ($F=2.57$, $p<.01$), and 3) within the DNA_i-DN_i variable between the levels of the distribution variable ($F=2.20$, $p<.01$). The Z test of equal means indicated that the means of the variable levels differ significantly ($p<.01$) for each of the situation variables found to be significant by the above sources F values (see Table 12).

Hypothesis 2.2a predicted that $(\overline{DNA_i}|I1)$ would not differ significantly from $(\overline{DNA_i}|I2)$. A Z test was employed to test this hypothesis and the difference was found to be not significant ($Z=0.0010$, n.s. two-tailed). Hypothesis 2.2b predicted that $(\overline{DNA_i}|S1)$ would not differ significantly from $(\overline{DNA_i}|S2)$. Again, a Z test indicated that the difference was not significant ($Z=0.4662$, n.s. two-tailed). Hypothesis 2.2c predicted that $(\overline{DNA_i}|C1)$ would not differ significantly from $(\overline{DNA_i}|C2)$. The results of the model comparison procedure and Z test indicated that the difference was significant at the $p<.01$ level, with the C1 level having the greater mean.

Hypothesis 2.3a predicted that $(\overline{DNA_i-DN_i}|S1)$ would be significantly smaller than $(\overline{DNA_i-DN_i}|S2)$. Although the results of the model comparison procedure and Z test indicated that there was a significant difference between the means, the S2 distribution level had the smaller mean.

Hypothesis 2.3b predicted that $(\overline{DNA_i - DN_i} | C1)$ would be significantly smaller than $(\overline{DNA_i - DN_i} | C2)$. A Z test was employed to test this hypothesis and the difference was found to be not significant ($Z=0.8642$, n.s. one-tailed).

Intrinsic Motivation and Decision Model Sensitivity

The model comparison procedure indicated that the intrinsic motivation factor had a significant effect on each of the four individual decision model sensitivity dependent variables.[1] The analysis of these effects requires additional tests. A product-moment correlation was computed for the intrinsic motivation factor with each of the four dependent variables. The results of these correlations are presented in Table 13. The weakness of these correlations can be expected given the relatively low explained variance associated with the various intrinsic motivation measure sums of squares.

The positive association between intrinsic motivation and the d'_i measure indicate that as the d'_i measure increased in size (approached the d'_k measure or used a single cutoff value) the subjects' intrinsic motivation measures increase. This result was confirmed by the positive association between the motivation factor and the DN_i measure. As either the variable response range decreases or the use of multiple cutoff values decreases (both are associated with increases in the DN_i measure) the subjects' intrinsic motivation measures increase. The substantial drop in the level of significance for the association between the intrinsic motivation and the DNA_i measures would suggest that

[1]See the last section in this chapter for a definition and for additional analyses concerning the intrinsic motivation factor.

TABLE 13

CORRELATION COEFFICIENTS FOR INTRINSIC MOTIVATION WITH INDIVIDUAL DECISION MODEL SENSITIVITY VARIABLES

Model	Intrinsic Motivation
d'_i	0.2045 (.059)
DN_i	0.2549 (.018)
DNA_i	0.1724 (.113)
DNA_i-DN_i	-0.1672 (.124)

Note: The numbers within the parentheses are the exact α-levels associated with the rejection of the null hypothesis that the correlation coefficient is equal to zero.

the association between the motivation factor and individual decision model sensitivity is only partially a result of the variable response range (the remaining effect within the DNA_i measure). This drop in the significance level could be explained by the negative association (albeit an equally low significance level) between the motivation factor and the DNA_i-DN_i measure. As the use of multiple cutoff values decreases (DNA_i-DN_i decreases) the subjects' intrinsic motivation measures increase.

Individual Decision Criteria

The following sections report the analyses and results of the individual decision criteria variables. The variables include the relative decision criteria, the relative decision criteria conservatism, and the relationships between individual attributes and decision criteria.

Relative Decision Criteria

Hypotheses 3.1 and 3.2 relate to the adjusted relative individual decision criteria. The adjustment concerns the elimination of the effects of multiple cutoff values on individual decision criteria. The variables which affect the adjusted relative decision criteria should be those related to the individual's selection of a cutoff value. Of the three situation variables the one most related to this selection is the cost variable.

The method of analysis was the model comparison procedure where the dependent variables are the BN_i, BNA_i, and BNA_i-BN_i measures. The independent variables are the three situation variables (with their

interactions), the three motivation factors, and the GPA_i variable. The three full models are:

$$\left.\begin{array}{l} BN_i \\ BNA_i \\ BNA_i - BN_i \end{array}\right| \begin{array}{l} = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \xi_i \\ \quad + \tau_i + \lambda_i + \delta_i \end{array}$$

The three model comparison procedure results are presented in Table 14, and the F values associated with the sources of the reduced models are presented in Table 15. The results indicate that the reduced BN_i model contains the distribution variable, the cost variable, and the extrinsic (monetary) motivation factor. Both the cost variable main effect and the motivation factor are significant at the $p<.01$ level, and the distribution variable main effect is significant at the $p<.10$ level. The reduced BNA_i model contains the cost variable and the extrinsic (monetary) motivation factor, and both are significant at the $p<.01$ level. The reduced BNA_i-BN_i model contains the cost variable and the GPA_i variable. The cost variable main effect is significant at the $p<.01$ level, and the GPA_i variable is significant at the $p<.10$ level.

The means, variances, and sample sizes for the dependent variables given the levels of the significant situation variables are included in Table 15. The F test of equal variances indicated that the following variances differ significantly: 1) within the BN_i variable between the levels of the distribution variable ($F=1.51$, $p<.10$), 2) within the BN_i variable between the levels of the cost variable ($F=6.11$, $p<.01$), 3) within the BNA_i variable between the levels of the cost variable ($F=9.36$, $p<.01$), and 4) within the BNA_i-BN_i variable between the levels of the cost variable ($F=39.74$, $p<.01$). Using a Z test of equal means, the means of the various levels were found to differ significantly

TABLE 14

MODEL COMPARISON PROCEDURE RESULTS FOR THE BN_i, BNA_i, AND BNA_i-BN_i DEPENDENT VARIABLES

Model	BN_i			BNA_i			BNA_i-BN_i		
	SSe	d.f.(F)	F	SSe	d.f.(F)	F	SSe	d.f.(F)	F
Full[d]	26.857	11,74	12.35[a]	40.102	11,74	10.76[a]	8.299	11,74	2.47[b]
Without 3-way interaction	27.387	1,74	1.46	40.107	1,74	0.01	8.716	1,74	3.72[c]
Without distribution x cost interaction	27.443	1,75	0.15	40.226	1,75	0.23	8.727	1,75	0.09
Without information x distribution interaction	27.491	1,75	0.29	40.222	1,75	0.22	9.137	1,75	3.62[c]
Without information x cost interaction	27.471	1,75	0.23	40.114	1,75	0.02	8.773	1,75	0.49
Without information[e]	28.415	1,78	2.23	41.707	1,78	2.61	9.258	1,78	0.43
Without distribution[e]	28.840	1,78	3.43[c]	41.359	1,78	1.94	9.217	1,78	0.09
Without cost[e]	70.389	1,78	120.73[a]	95.941	1,78	107.44[a]	10.562	1,78	11.48[a]

[a] $p<.01$ [b] $p<.05$ [c] $p<.10$

[d] The F value associated with the full model is the test of the full model and not a model comparison test.

[e] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 15

PARAMETER VALUES ASSOCIATED WITH THE REDUCED BN_j, BNA_j, AND BNA_j-BN_j MODELS

F Values Associated With the Sources of the Reduced Models

Source	BN_j d.f.	BN_j F	BNA_j d.f.	BNA_j F	BNA_j-BN_j d.f.	BNA_j-BN_j F
Distribution	1,79	3.29[c]				
Cost	1,79	120.57[a]	1,80	105.60[a]	1,80	11.91[a]
Intrinsic motivation	1,79	0.33	1,80	0.26	1,80	2.00
Extrinsic (non-monetary) motivation	1,79	0.02	1,80	0.08	1,80	0.01
Extrinsic (monetary) motivation	1,79	10.16[a]	1,80	7.24[a]	1,80	0.17
GPA	1,79	0.49	1,80	2.11	1,80	3.86[c]

Means and Variances Associated With the Significant Variables

Variable Level	BN_j N	BN_j Mean	BN_j Variance	BNA_j N	BNA_j Mean	BNA_j Variance	BNA_j-BN_j N	BNA_j-BN_j Mean	BNA_j-BN_j Variance
S1	44	1.0458	0.71977	44	1.1873	0.93408	44	0.0968	0.06872
S2	42	1.2272	1.08552	42	1.3572	1.54782	42	0.1280	0.20420
C1	47	1.7777	0.63707	47	2.0046	0.96602	47	0.2269	0.21259
C2	39	0.3591	0.10422	39	0.3853	0.10326	39	0.0263	0.00535

$p<.01$ $p<.05$ $p<.10$

($p<.01$) for each of the situation variables found to be significant by the above sources F values. The sole exception was the distribution variable within the BN_i measure. The means of the distribution levels within the BN_i variable do not differ significantly ($Z=0.8830$, n.s. two-tailed).

Hypothesis 3.1a predicted that $(\overline{BNA_i}|I1)$ would not differ significantly from $(\overline{BNA_i}|I2)$. A Z test indicated that the difference was not significant ($Z=0.7891$, n.s. two-tailed). Hypothesis 3.1b predicted that $(\overline{BNA_i}|S1)$ would not differ significantly from $(\overline{BNA_i}|S2)$. Again, a Z test showed the difference to be not significant ($Z=0.7048$, n.s. two-tailed). Hypothesis 3.1c predicted that $(\overline{BNA_i}|C1)$ would be significantly larger than $(\overline{BNA_i}|C2)$. The model comparison procedure and Z test indicated a significant difference at the $p<.01$ level, with the C1 level having the larger mean. Hypothesis 3.2 predicted that the variance of $(\overline{BNA_i}|C1)$ would be significantly smaller than the variance of $(\overline{BNA_i}|C2)$. The F test of equal variances resulted in a finding of a significant difference at the $p<.01$ level, with the C2 level having the smaller variance.

Hypothesis 3.4a predicted that $(\overline{BNA_i-BN_i}|S1)$ would be significantly smaller than $(\overline{BNA_i-BN_i}|S2)$. A Z test of equal means indicated that the difference was not significant ($Z=0.3892$, n.s. one-tailed): however, the obtained direction is the same as the predicted direction of this effect. Hypothesis 3.4b predicted that $(\overline{BNA_i-BN_i}|C1)$ would be significantly smaller than $(\overline{BNA_i-BN_i}|C2)$. The model comparison procedure and Z test indicated that the difference was significant at the $p<.01$ level, with the C2 level having the smaller mean.

Relative Decision Criteria Conservatism

Hypothesis 3.3 relates to the effect of conservatism on the relative individual decision criteria. The hypothesis proposes that the greater the difference between the individual's initial decision anchor and the optimal cutoff value, the higher the level of conservatism. The situation variable most related to such a difference is the cost variable.

The method of analysis was the model comparison procedure where the dependent variable is the BNC_i measure and the independent variables are the three situation variables (with their interactions), the three motivation factors, and the GPA_i variable. The full BNC_i model is:

$$BNC_i = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \xi_i + \tau_i + \lambda_i + \delta_i$$

The model comparison procedure results are presented in Table 16, and the F values associated with the sources of the reduced BNC_i model are presented in Table 17. The results indicate that the reduced BNC_i model contains the cost variable, the extrinsic (monetary) motivation factor, and the GPA_i variable. Both the cost variable main effect and the GPA_i variable are significant at the $p<.05$ level. The extrinsic (monetary) motivation factor is significant at the $p<.01$ level.

The means, variances, and sample sizes of the BNC_i measure given the levels of the cost variable are included in Table 17. Using the F test of equal variances, the variances of the BNC_i given the levels of the cost variable were found to differ significantly ($F=9.36$, $p<.01$).

TABLE 16

MODEL COMPARISON PROCEDURE RESULTS FOR THE BNC_i DEPENDENT VARIABLE

Model	SSe	d.f.(F)	F
Full[b]	38.249	11,74	2.35[a]
Without 3-way interaction	38.510	1,74	0.51
Without distribution x cost interaction	39.291	1,75	1.52
Without information x distribution interaction	38.543	1,75	0.06
Without information x cost interaction	38.624	1,75	0.22
Without information[c]	39.895	1,78	0.91
Without distribution[c]	39.607	1,78	0.34
Without cost[c]	42.778	1,78	6.61[a]

[a] $p<.05$

[b] The F value associated with the full model is the test of the full model and not a model comparison test.

[c] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 17

PARAMETER VALUES ASSOCIATED WITH THE REDUCED BNC_i MODEL

F Values Associated With the Sources of the Reduced Model

Source	d.f.	F
Cost	1,80	6.88[b]
Intrinsic motivation	1,80	2.61
Extrinsic (non-monetary) motivation	1,80	0.04
Extrinsic (monetary) motivation	1,80	7.79[a]
GPA	1,80	4.90[b]

Means and Variances Associated With the Significant Sources

Variable Level	N	Mean	Variance
C1	47	1.0046	0.96602
C2	39	0.6147	0.10326

[a]$p<.01$

[b]$p<.05$

The Z test of equal means indicated that the means of the cost levels differ significantly ($Z=2.5598$, $p<.05$ two-tailed), with the C2 level having the smaller mean.

Hypothesis 3.3a predicted that $(\overline{BNC_i}|I1)$ would not differ significantly from $(\overline{BNC_i}|I2)$. A Z test indicated that the difference was not significant ($Z=0.6802$, n.s. two-tailed). Hypothesis 3.3b predicted that $(\overline{BNC_i}|S1)$ would not differ significantly from $(\overline{BNC_i}|S2)$. Again, a Z test indicated that the difference was not significant ($Z=0.3295$, n.s. two-tailed). Hypothesis 3.3c predicted that $(\overline{BNC_i}|C1)$ would be significantly smaller than $(\overline{BNC_i}|C2)$. The model comparison procedure and Z test indicated that the difference was significant at the $p<.05$ level, with the C2 level having the smaller mean.

Individual Attributes and Decision Criteria

The model comparison procedure results indicated that the extrinsic (monetary) motivation factor and the GPA_i variable had significant effects upon the various individual decision criteria variables.[2] The analysis of these effects also required additional tests. A product moment correlation was computed for the motivation factor and the GPA_i variable with each of the decision criteria dependent variables. The results of these correlations are presented in Table 18.

The negative association between extrinsic (monetary) motivation and the BN_i variable indicates that as the BN_i measure increases the subjects' extrinsic (monetary) motivation measures decrease. The BN_i

[2]See the last sections in this chapter for definitions and for additional analyses concerning the extrinsic (monetary) motivation factor and the GPA_i variable.

TABLE 18

CORRELATION COEFFICIENTS FOR EXTRINSIC (MONETARY) MOTIVATION AND SUBJECT GPA WITH INDIVIDUAL DECISION CRITERIA VARIABLES

Model	Extrinsic (Monetary) Motivation	Subject GPA
BN_i	-0.1975 (.068)	-0.0468 (.669)
BNA_i	-0.1916 (.077)	-0.1000 (.360)
BNA_i-BN_i	-0.0564 (.606)	-0.1896 (.080)
BNC_i	-0.2951 (.006)	-0.2346 (.030)

Note: The numbers within the parentheses are the exact α-levels associated with the rejection of the null hypothesis that the correlation coefficient is equal to zero.

measure approaches infinity as the distance between the β_i measure and the β_k measure increases. A similar association exists between the motivation factor and the BNA_i measure (the BNA_i measure eliminates the effects of multiple cutoff values). The BNA_i-BN_i variable, which measures the effect of multiple cutoff values upon individual decision criteria, has no significant association with the motivation factor. The BNC_i variable, which measures the effect of conservatism upon individual decision criteria, has a stronger negative association with the motivation factor. As the level of conservatism increases (BNC_i increases) subjects' extrinsic (monetary) motivation measures decrease.

The negative association between the GPA_i variable and the BNA_i-BN_i variable indicates that as the BNA_i-BN_i variable increases the subjects' GPA_is decrease (the BNA_i-BN_i measure increases as multiple cutoff value usage increases). The negative association between the GPA_i variable and the BNC_i variable indicates that as the subjects' GPA_is decrease the level of conservatism increases.

Individual Long-Run Decision Efficiency

The following sections report the analyses and results of the individual long-run decision efficiency variables. The variables include the relative decision costs, the relationships between individual attributes and long-run decision efficiency, and the relationships between long-run decision efficiency and training phase performance.

Relative Decision Costs

Hypotheses 4.1, 4.2, and 4.3 relate to the decision costs incurred by the individuals relative to the decision costs incurred by the optimal

models. Both the stated objective function and subject payoff function involved the minimization of the decision costs. A subject's long-run decision efficiency was measured in terms of his minimization of his decision costs relative to those of an optimal model.

The method of analysis was the model comparison procedure where the dependent variables are the G_i, GP_i, and GN_i measures. The independent variables are the three situation variables (with their interactions), the DN_i variable, the three motivation factors, and the GPA_i variable. Ideally, both the DN_i and BN_i variables should be included in the model: however, the BN_i variable had significantly greater association with the other independent variables than did the DN_i variable (the R^2 for the full BN_i model was 0.6474, whereas the R^2 for the full DN_i model was 0.2192). Inclusion of the BN_i variable would produce a significant problem of multicolinearity. The three full models are:

$$\left.\begin{array}{l} G_i \\ GP_i \\ GN_i \end{array}\right| \begin{array}{l} = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \psi_i + \xi_i \\ \quad + \tau_i + \lambda_i + \delta_i \end{array}$$

The three model comparison procedure results are presented in Table 19, and the F values associated with the sources of the reduced models are presented in Table 20. The results indicate that the reduced G_i model contains the distribution by cost interaction and the DN_i variable. Both the interaction and the DN_i variable are significant at the $p<.01$ level. The reduced GP_i model contains the distribution by cost interaction, the DN_i variable, the intrinsic motivation factor, the extrinsic (monetary) motivation factor, and the GPA_i variable. The interaction, extrinsic motivation factor, and GPA_i variable are significant at the $p<.05$ level. The interaction,

TABLE 19

MODEL COMPARISON PROCEDURE RESULTS FOR THE G_i, GP_i, AND GN_i DEPENDENT VARIABLES

Model	G_i SSe	G_i d.f.(F)	G_i F	GP_i SSe	GP_i d.f.(F)	GP_i F	GN_i SSe	GN_i d.f.(F)	GN_i F
Full[c]	0.0809	12,73	12.08[a]	0.1824	12,73	7.46[a]	0.0349	12,73	2.67[a]
Without 3-way interaction	0.0811	1,73	0.17	0.1824	1,73	0.00	0.0352	1,73	0.52
Without distribution x cost interaction	0.0895	1,74	7.71[a]	0.1953	1,74	5.21[b]	0.0356	1,74	0.96
Without information x distribution interaction	0.0812	1,74	0.09	0.1824	1,74	0.01	0.0352	1,74	0.06
Without information x cost interaction	0.0814	1,74	0.26	0.1826	1,74	0.07	0.0352	1,74	0.03
Without information[d]	0.0826	1,76	1.05	0.1835	1,76	0.36	0.0357	1,77	0.05
Without distribution[d]							0.0360	1,77	0.71
Without cost[d]							0.0369	1,77	2.60

[a] $p<.01$ [b] $p<.05$

[c] The F value associated with the full model is the test of the full model and not a model comparison test.

[d] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 20

PARAMETER VALUES ASSOCIATED WITH THE REDUCED G_i, GP_i, AND GN_i MODELS

F Values Associated With the Sources of the Reduced Models

Source	G_i		GP_i		GN_i	
	d.f.	F	d.f.	F	d.f.	F
Distribution	1,70	0.51	1,70	0.77		
Cost	1,70	2.56	1,70	0.11		
Distribution x cost	1,70	7.92[a]	1,70	5.39[b]		
DN_i	1,70	88.76[a]	1,70	46.39[a]	1,80	0.90
Intrinsic motivation	1,70	2.40	1,70	3.95[c]	1,80	5.00[b]
Extrinsic (non-monetary) motivation	1,70	0.00	1,70	0.01	1,80	0.05
Extrinsic (monetary) motivation	1,70	1.71	1,70	4.33[b]	1,80	7.59[a]
GPA	1,70	2.39	1,70	5.93[b]	1,80	9.82[a]

Means and Variances Associated With the Significant Variables

Variable Level	G_i			GP_i		
	N	Mean	Variance	N	Mean	Variance
S1, C1	24	0.0504	0.00229	24	0.0987	0.00456
S1, C2	20	0.0921	0.00371	20	0.1372	0.00538
S2, C1	23	0.0430	0.00097	23	0.0886	0.00297
S2, C2	19	0.0575	0.00375	19	0.0934	0.00576

[a] $p<.01$ [b] $p<.05$ [c] $p<.10$

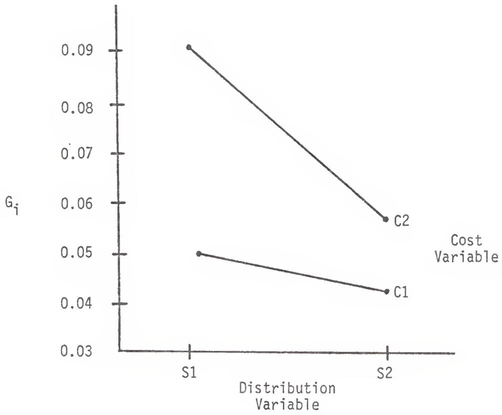
extrinsic motivation factor, and GPA_i variable are significant at the $p<.05$ level. The DN_i variable is significant at the $p<.01$ level and the intrinsic motivation factor is significant at the $p<.10$ level. The reduced GN_i model contains the intrinsic motivation factor, the extrinsic (monetary) motivation factor, and the GPA_i variable. Both the extrinsic motivation factor and the GPA_i variable are significant at the $p<.01$ level and the intrinsic motivation factor is significant at the $p<.05$ level.

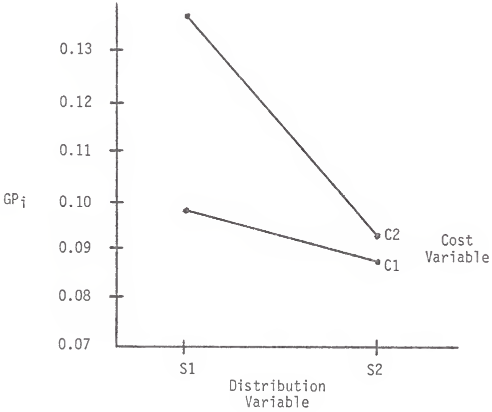
The means, variances, and sample sizes for the distribution by cost interaction within the G_i and GP_i models are included in Table 20. Figure 7 presents a graphic representation of both distribution by cost interactions. Bartlett's test for homogeneity of variances indicted that the variances within the G_i model distribution by cost interaction are significantly heterogeneous ($\chi^2=10.66$, $p<.05$ with 3 d.f.). The variances within the GP_i model distribution by cost interaction are considered homogeneous ($\chi^2=2.52$, $p<.25$ with 3 d.f.). Duncan's multiple range test of equal means indicated that the means within the G_i model distribution by cost interaction form two groups: the means within a group do not differ significantly ($p=.01$) but a significant difference ($p=.01$) exists for the means between groups. These groups are 1) $(\overline{G}_i|S1,C2)$ and $(\overline{G}_i|S2,C2)$, and 2) $(\overline{G}_i|S2,C1)$, $(\overline{G}_i|S1,C1)$, and $(\overline{G}_i|S2,C2)$.

Hypothesis 4.1 predicted that the variance of $(G_i|C1)$ would be significantly smaller tha n the variance of $(G_i|C2)$. Using the F test of equal variances, the variances differ significantly ($F=2.43$, $p<.01$), with $(G_i|C1)$ having the smaller variance. Hypothesis 4.3 predicted a significant distribution by cost interaction within the G_i model in

FIGURE 7

DISTRIBUTION BY COST VARIABLE INTERACTION WITHIN G_i AND GP_i MODELS


0.09
0.08
0.07
G_i
0.06
0.05
0.04
0.03
C2
C1
Cost
Variable
S1
S2
Distribution
Variable


0.13
0.12
0.11
GP_i
0.10
0.09
0.08
0.07
C2
C1
Cost
Variable
S1
S2
Distribution
Variable

which the $(\overline{G}_i|S1,C1)-(\overline{G}_i|S2,C1)$ would be smaller than the $(\overline{G}_i|S1,C2)-(\overline{G}_i|S2,C2)$. The results of the model comparison procedure indicated a significant distribution by cost interaction ($p<.01$), with the $(\overline{G}_i|S1,C1)-(\overline{G}_i|S2,C1)$ equal to 0.0074 and the $(\overline{G}_i|S1,C2)-(\overline{G}_i|S2,C2)$ equal to 0.0346. Hypothesis 4.2a predicted that $(\overline{G}_i|C1)$ would be significantly smaller than $(\overline{G}_i|C2)$. A Z test of equal means indicated that the means differ significantly ($Z=2.4420$, $p<.01$ one-tailed), with the C1 level having the smaller mean. The lack of significance for the cost variable main effect within the model comparison procedure could be the result of the distribution by cost interaction. There exists substantially less difference between the levels of the cost variable when given S2 distribution level than when given the S1 distribution level. Hypothesis 4.2b predicted that $(\overline{G}_i|S2)$ would be smaller than $(\overline{G}_i|S1)$. A Z test of equal means indicated that the means differ significantly ($Z=1.7452$, $p<.05$ one-tailed), with the S2 level having the smaller mean. The lack of significance within the model comparison procedure for the distribution main effect was predicted by hypothesis 4.2b. Hypothesis 4.2c predicted that $(\overline{G}_i|I1)$ would not differ significantly from $(\overline{G}_i|I2)$. Using a Z test of equal means, the difference was found to be not significant ($Z=0.4528$, n.s. two-tailed).

Hypotheses 4.4a and 4.4b relate to the ratio of the individual's relative additional decision costs to the individual's relative additional decision savings. The method of analysis was the model comparison procedure where the dependent variable is the GP_i/GN_i variable, and the independent variables are the same as for the full G_i model. The full GP_i/GN_i model is:

$$GP_i/GN_i = \mu + \alpha_j + \beta_k + \gamma_l + \alpha\beta_{jk} + \alpha\gamma_{jl} + \beta\gamma_{kl} + \alpha\beta\gamma_{jkl} + \psi_i + \xi_i + \tau_i + \lambda_i + \delta_i$$

The model comparison procedure results are presented in Table 21, and the F values associated with the sources of the reduced model are presented in Table 22. The results indicate that the reduced GP_i/GN_i model contains the distribution by cost interaction and the DN_i variable, both significant at the $p<.01$ level.

The means, variances, and sample sizes of the distribution by cost interaction are included in Table 22. Figure 8 presents a graphic representation of the distribution by cost interaction. Bartlett's test of homogeneity of variances indicated that the variances within the distribution by cost interaction are homogeneous ($\chi^2=1.068$, $p<.25$ with 3 d.f.). Duncan's multiple range test of equal means indicated that the means within the distribution by cost interaction form two overlapping groups: the means within a group do not differ significantly ($p=.01$), whereas the means between groups do differ significantly ($p=.01$). These groups are 1) $(\overline{GP_i/GN_i}|C2,S1)$, $(\overline{GP_i/GN_i}|C2,S2)$, and $(\overline{GP_i/GN_i}|C1,S2)$; and 2) $(\overline{GP_i/GN_i}|C1,S1)$, $(\overline{GP_i/GN_i}|C1.S2)$, and $(\overline{GP_i/GN_i}|C2,S2)$.

Hypothesis 4.4b predicted a significant distribution by cost variable interaction in which the $(\overline{GP_i/GN_i}|C2,S2)-(\overline{GP_i/GN_i}|C1,S2)$ would be smaller than $(\overline{GP_i/GN_i}|C2,S1)-(\overline{GP_i/GN_i}|C1,S1)$. The results of the model comparison procedure indicated a significant distribution by cost interaction ($p<.01$). The $(\overline{GP_i/GN_i}|C2,S2)-(\overline{GP_i/GN_i}|C1,S2)$ was equal to 0.0618, and the $(\overline{GP_i/GN_i}|C2,S1)-(\overline{GP_i/GN_i}|C1,S1)$ was equal to 1.1086. Hypothesis 4.4a predicted that $(\overline{GP_i/GN_i}|C1)$ would be significantly smaller than $(\overline{GP_i/GN_i}|C2)$. Using a Z test of equal means, the difference between the means was found to be significant ($Z=2.0109$, $p<.01$ one-tailed), with the C1 level having the smaller mean. The lack of

TABLE 21

MODEL COMPARISON PROCEDURE RESULTS FOR THE GP_i/GN_i DEPENDENT VARIABLE

Model	SSe	d.f.(F)	F
Full[b]	66.265	12,66	6.91[a]
Without 3-way interaction	67.538	1,66	1.27
Without distribution x cost interaction	76.352	1,67	8.74[a]
Without information x distribution interaction	67.607	1,67	0.07
Without information x cost interaction	69.242	1,67	1.69
Without information[c]	70.493	1,69	1.17

[a] $p<.01$

[b] The F value associated with the full model is the test of the full model and not a model comparison test.

[c] The test of this model assumes the effects of those interactions that include this variable are equal to zero.

TABLE 22

PARAMETER VALUES ASSOCIATED WITH THE REDUCED GP_i/GN_i MODEL

F Values Associated With the Sources of the Reduced Model

Source	d.f.	F
Distribution	1,70	0.64
Cost	1,70	0.35
Distribution	1,70	8.85[a]
DN_i	1,70	59.01[a]
Intrinsic motivation	1,70	0.11
Extrinsic (non-monetary) motivation	1,70	0.54
Extrinsic (monetary) motivation	1,70	0.09
GPA	1,70	2.54

Means and Variances Associated With the Significant Sources

Variable Level	N	Mean	Variance
S1, C1	24	2.0189	1.42035
S1, C2	19	3.1275	2.12453
S2, C1	19	2.3372	2.09340
S2, C2	17	2.3990	1.71284

[a] $p<.01$

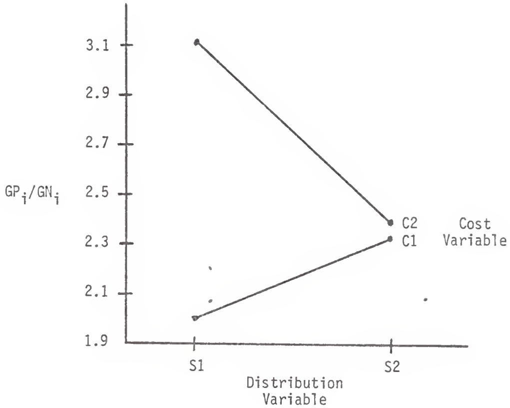


FIGURE 8

DISTRIBUTION BY COST INTERACTION WITHIN THE GP_i/GN_i MODEL

significance for the cost variable main effect within the model comparison procedure could be the result of the distribution by cost interaction. The cost variable has a significant effect only when given the S1 distribution level.

Individual Attributes and Long-Run Decision Efficiency

The model comparison procedure results indicated that the DN_i variable, the intrinsic motivation factor, the extrinsic (monetary) motivation factor, and the GPA variable had significant effects upon various individual long-run decision efficiency measures.[3] The analysis of these effects required additional tests. A product-moment correlation was computed for each of these individual attributes with each of the dependent variables. The results of these correlations are presented in Table 23.

The negative association between the G_i variable and the DN_i variable indicates that as the relative net decision costs increase the subjects' variable response ranges increase (DN_i increases). The same association exists between the GP_i variable and the DN_i variable: as relative additional decision costs increase the subjects' variable response ranges increase. The positive association between the GN_i variable and the DN_i variable indicates that as the relative additional decision savings increase the subjects' variable response ranges decrease (DN_i decreases). The GP_i/GN_i variable and the DN_i variable were associated negatively: as the relative additional decision costs

[3]See the last sections in this chapter for definitions and additional analyses concerning these individual attributes.

TABLE 23

CORRELATION COEFFICIENTS FOR INDIVIDUAL ATTRIBUTES WITH LONG-RUN DECISION EFFICIENCY

Individual Attribute	G	GP	GN	GP /GN
DN	-0.7616 (.001)	-0.6528 (.001)	0.1868 (.085)	-0.6613 (.001)
Intrinsic motivation	-0.2854 (.008)	-0.3044 (.004)	0.2399 (.026)	-0.1758 (.121)
Extrinsic (monetary) motivation	-0.1071 (.327)	-0.1887 (.081)	0.3018 (.005)	0.0185 (.871)
GPA	-0.1737 (.110)	-0.2526 (.019)	0.3377 (.002)	0.0861 (.450)

Note: The numbers within the parentheses are the exact α-levels associated with the rejection of the null hypothesis that the correlation coefficient is equal to zero.

increase at a rate greater than the relative additional decision savings the subjects' variable response ranges increase.

The negative association between the G_i variable and the intrinsic motivation factor indicates that as the relative net decision costs increase the subjects' intrinsic motivation measures decrease. The same association exists between the GP_i variable and the intrinsic motivation factor: as the relative additional decision costs increase the subjects' intrinsic motivation measures decrease. The GN_i variable and the intrinsic motivation factor were associated positively: as the relative additional decision savings increase the subjects' intrinsic motivation measures increase.

Similar associations exist for the extrinsic (monetary) motivation factor. Thus, as the relative additional decision costs increase (GP_i increases) the subjects' extrinsic (monetary) motivation measures decrease. Conversely, as the relative additional decision savings increase (GN_i increases) the subjects' extrinsic (monetary) motivation measures increase.

The negative association between the GP_i variable and the GPA_i variable indicates that as subjects' GPAs decrease relative additional decision costs increase. Likewise, the positive association between the GN_i variable and the GPA variable indicates that as subjects' GPAs increase relative additional decision savings increase.

Long-Run Decision Efficiency and Training Phase Performance

Hypothesis 4.5 predicted that those subjects in the PP classification of training adjustment direction would have a signficantly smaller mean G_i than those subjects in the MM classification. A t-test

was used to test this hypothesis. The $(\overline{G}_i|PP)$ was 0.0536 and the $(\overline{G}_i|MM)$ was 0.0780. The F test for equal variances indicated that the variances were equal (F=1.6378, n.s.). The t-test for the hypothesis of equal means indicated that the hypothesis could be rejected at the $p<.10$ level ($t=1.303$ with 41 d.f.).

Hypothesis 4.6 predicted that those subjects in the mixed classifications (PM and MP) of training adjustment direction would have mean G_i measures between the non-mixed classifications. The $(\overline{G}_i|PM)$ was 0.0603 and the $(\overline{G}_i|MP)$ was 0.0577. Since the hypothesis did not predict significance (and because of the results of hypothesis 4.5), these means were not tested statistically. The directional prediction of hypothesis 4.6 was supported.

Individual Attributes

The following sections report the analyses and results of two individual attributes: subject grade point average and subject motivations. The objective of both analyses was the determination of the significance of any between-group variance of these attributes.

Subject Grade Point Average

Grade point averages (GPAs) of subjects were analyzed to determine whether this individual attribute varied between groups of subjects. A systematic variance of this attribute between groups could bias the interpretation of the effects of the independent variables on particular observation variables. Two methods of analysis were used to test the association of GPA with the independent variables: Duncan's multiple range test and Bartlett's test of homogeneity of variance.

Duncan's multiple range test was used to determine if the subjects' mean GPAs differed between the eight independent variables conditions. Given a completely between-subject assignment these eight groups represented the results of the experimental sampling plan. The results indicate that there were not significant differences ($p=.01$) between the mean GPAs of these eight groups. Bartlett's test of homogeneity of variance was used to test the variances of the GPAs for these eight groups. The results indicate that the hypothesis of homogeneity of variance could not be rejected ($\chi^2=7.6906$ with 7 d.f., $p<.50$).

Overall, the results indicate that between-group variance should not be affected significantly by differences between subjects' GPAs. This does not indicate, however, that within-group variance will not be affected by the differences between GPAs. The possible effects of within-group GPA variance were presented above.

Subject Motivations

The objective underlying the analysis of subject motivations was similar to that relating to subject GPAs: i.e., the analysis was performed to determine whether motivations varied between groups of subjects. The initial stage of this analysis consisted of reducing the ten motivation scale items into several motivation factors using the technique of factor analysis. The subjects' responses to the ten motivation scale items were factor analyzed using a varimax rotation for a four factor solution. The four factor solution was chosen on the basis of prior beliefs concerning the general dimensions (or sources) of subject motivations: intrinsic motivation, extrinsic non-monetary motivation, extrinsic monetary motivation, and general motivation not

clearly associated with any one of the previous sources. The rotated factor pattern for the ten scale items is presented in Table 24. Analyzing the eigenvalues of these factors, the sharpest break (or decline in slope) occurred between the third and fourth factor. For this reason only the first three factors are included within the subject motivation analysis. The first three factors account for 62.1 percent of the variability in the motivation scale items.

The first motivation factor had heavy positive loadings on the scale items "enjoy making the decisions," "satisfied with performance," and "enjoy overall experience of participating." The first motivation factor was interpreted as basically measuring <u>intrinsic motivation</u> stimulated by enjoyment of the experiment and the required task.

The second motivation factor had heavy positive loadings on the scale items "desire to perform well," "desire to cooperate with the experimenter," and "desire to contribute to research knowledge." This factor was interpreted as basically measuring <u>extrinsic motivation</u> stimulated by <u>non-monetary</u> sources.

The third motivation factor had heavy positive loadings on the scale items "try less hard if money rewards halved" and "money rewards caused you to try harder than without them." The third motivation factor was interpreted as basically measuring <u>extrinsic motivation</u> stimulated by <u>monetary</u> sources.

Using an orthogonal transformation matrix the individual scale items were transformed into individual factor scores for each of the first three motivation factors. Two methods of analysis were used to test the association of subject motivation with the independent variables: Duncan's multiple range test and Bartlett's test of homogeneity of variance.

TABLE 24

VARIMAX ROTATED MOTIVATION FACTOR PATTERN AND DESCRIPTION OF MOTIVATION SCALE ITEMS

Scale Item	Factor 1	Factor 2	Factor 3	Factor 4
1	0.1399	0.2336	-0.2112	-0.7551
2	0.2610	0.7485	0.0327	0.0503
3	0.8287	0.2336	-0.0712	-0.0359
4	0.8001	-0.1721	0.2190	-0.0836
5	-0.0305	0.0197	0.9037	0.1436
6	-0.1229	0.2524	-0.0876	0.8044
7	0.0231	0.8198	0.0104	0.0174
8	0.0814	0.1075	0.8789	-0.0385
9	0.7324	0.3174	-0.0963	-0.3140
10	0.0148	0.7586	0.0848	-0.0441
Eigenvalue	2.6975	1.8552	1.6548	0.9528
Cum Eigenvalue Portion	0.2700	0.4550	0.6210	0.7160

Description of Motivation Scale Items

1 Number of times willing to participate in the future.
2 Desire to perform well in undertaking a challenging task.
3 Enjoy making the decisions.
4 Satisfied with your performance.
5 Would have tried less hard if money rewards had been halved.
6 Feel tense during the experiment.
7 Desire to cooperate with the experimenter.
8 Money rewards caused you to try harder than without them.
9 Enjoy the overall experience of participation.
10 Desire to contribute to research knowledge.

Duncan's multiple range test was used to determine if the subjects' motivations differed between the eight independent variables conditions. The results indicate that there were no significant differences ($p=.01$) in the mean motivation factors between the eight groups. Bartlett's test of homogeneity of variance was used to test the variances of the three motivation factors for these eight groups. The results indicate that the hypothesis of homogeneity of variance could not be rejected for the second and third motivation factors ($\chi^2=10.9095$ with 7 d.f., $p<.25$; $\chi^2=1.796$ with 7 d.f., $p<.95$). The hypothesis of homogeneity of variance could be rejected at the $p<.10$ level for the first motivation factor ($\chi^2=12.7829$ with 7 d.f.).

Overall, the results indicate that between-group variance should not be affected significantly by differences between the subjects' motivations. Again, the analysis does not indicate that within-group variance will be unaffected by the differences between subjects' motivations: these possible effects were presented above.

CHAPTER VI

DISCUSSION OF RESULTS

Conceptual Development Revisited

A brief restatement of the conceptual development presented in Chapter III will serve as a basis for discussion of the results that were reported in Chapter V. It was posited that an individual's long-run decision efficiency would be affected by 1) the structure of the particular decision situation, 2) the contents of the available information set, 3) the individual's efficiency in processing the available information, and 4) the individual's ability to expand the available information through experience with the particular situation. A general heuristic was expected to systematically account for a portion of the decision behavior of the subjects. A heuristic, within this context, refers to a learned set of rules or principles which are utilized by individuals in making the particular decisions required of them. Since a heuristic is a learned response to some decision task stimuli, individual characteristics can have considerable effect upon the specific form of the heuristic. The conceptual development, however, proposed that specific decision task stimuli would give rise to general forms of heuristics which would be (at least partially) independent of individual characteristics.

The decision task utilized in this research required the discrimination between the uncertain existence of two states of nature

(in-control and out-of-control) for a given production labor process. A random variable produced by the accountant provided evidence concerning state existance at particular points in time. This random variable (the labor efficiency variance) had certain statistical properties within the states of nature: the decision maker either had or did not have knowledge of these particular properties. The decision task was complicated by the existence of unequal values (costs) associated with the various possible decision outcomes.

The form of the general heuristic proposed to describe decision making behavior was that of anchoring and adjustment. Anchoring and adjustment first requires the selection of an initial decision value (anchor) from the continuum of possible decision values that are located within the domain of the random variable (the labor efficiency variance in the case of the present study). Once an initial decision anchor is selected by the decision maker, training and experience (learning) will lead to adjustments in the value of the anchor. Such adjustments will be motivated primarily by feedback of various decision performance measures. Should a particular decision performance measure indicate less than satisfactory decision performance, the decision maker will be motivated to adjust his decision anchor in an attempt to improve decision performance measures in the future. The concept of less than satisfactory decision performance assumes that the decision maker has internalized the objective function from which the decision performance measure was derived. Within this research the decision performance objective function had a homomorphic relation with the decision maker's payoff function.

Overall Results

The overall results generally are supportive of the conceptual development. The major deviations from the hypotheses derived from the conceptual development and the simulations are summarized in this section. Plausible explanations, consistent with the observed results, are developed for those situations where the results deviated from the hypotheses. These explanations, ex post in nature, have not been tested by this research: they are offered as potential modifications to the existing conceptual development and can be tested by future research.

First, within situations where the state distributions had wider separation and the adjustment process involved divergence from the standard, subjects' initial decision anchors were biased toward the standard. The extent of this bias was not large and as the adjustment process continued the bias was reduced substantially relative to the adjustment bias of subjects within the opposite situations.

Second, variable response ranges were larger within situations where the adjustment process involved divergence from the standard, and decision criteria conservatism was larger within situations where the adjustment process involved convergence toward the standard. Although these effects were contrary to those predicted, the concept of a subjective adjustment limit provides a plausible explanation. The concept proposes that subjects will perceive the standard as a subjective adjustment limit and will be hesitant to approach the standard. This subjective limit will have an effect where the situation involves adjustment toward the standard. If this phenomenon does exist it would affect both the variable response range and the decision criteria conservatism in the same manner as the obtained results.

Third, the obtained effects of the situation variables on the relative decision costs were weaker than those predicted. The predicted effects were based, in part, upon the assumption of equal learning efficiency between the levels of the various situation variables. However, as indicated earlier the obtained learning efficiencies were not equal between various situation variable levels. A plausible explanation for the weaker obtained effects of the situation variables on the relative decision costs utilizes the unequal learning efficiency results. That is, the incorporation of unequal learning efficiencies within the prediction of the effects of the situation variables on the relative decision costs will produce expected effects with strengths similar to the obtained effects.

Finally, multiple decision anchor usage had greater effects upon individual decision model sensitivity within situations where the state distributions were closer together and had smaller variance. It had greater effects on individual decision criteria within situations where the decision costs favored making investigation decisions for smaller (in absolute value) labor efficiency variances. Both of these results are contrary to those predicted, and no explanations are offered.

Overall, the variable which had the largest impact on the relative decision costs was the subjects' decision criteria conservatism. The mean DNA_i measure over all subjects was 0.926. Considering that a value of one would indicate variable response ranges were not used, the subjects' overall decision model sensitiviy was approximately that of the optimal model. The mean BNC_i over all subjects was 0.828. This indicated that the average distance between the subjects' decision criteria and the optimal model's decision criteria was 82.8 percent of that of the optimal model. This was supported by the mean RA_i over

all subjects: the overall mean RA_i was 0.641 which indicated that the subjects adjusted their decision anchors only 35.9 percent ($1-\overline{RA}_i$) of the distance between their initial decision anchors and the optimal model's decision value. However, even given this level of overall decision criteria conservatism, the mean relative decision costs ($\overline{G}_i$) over all subjects was 0.06 (the average subject's total decision costs were 6.0 percent greater than the optimal model's total decision costs).

The deviation of the G_i measure from a value of zero has been attributed to the following factors: 1) variable response ranges, 2) multiple decision anchors, and 3) decision criteria conservatism. Although each factor was affected differently by various situation variables and individual attributes, the overall effects of these factors on the relative decision costs indicate their relative importance. The overall effect of variable response ranges was shown to be negligible. Ignoring the variable response range effects, the overall relative decision efficiency measure (G_i) can be adjusted into submeasures which are affected by only one of the two remaining factors. Eliminating the effects of multiple decision anchors, the adjusted $\overline{G}_i$ measure was 0.045. This indicated that of the total deviation of the subjects' decision costs from those of the optimal models, approximately 75 percent was due to individual decision criteria conservatism and approximately 25 percent was due to multiple decision anchors.

Discussion of Results

The following discussion of results is organized according to decision processes and dependent variables. The discussion includes decision anchor adjustment, individual decision model sensitivity,

individual decision criteria conservatism, and individual long-run decision efficiency.

Decision Anchor Selection and Adjustment

The first aspect of the anchoring and adjustment heuristic is the selection of the initial decision anchor. The formation of the hypotheses concerned with this aspect was based upon the assumptions that 1) individuals (within a given level of distribution variable) would tend to use a common initial decision anchor, and 2) the location of this common anchor would be related to a measure of central tendency between the two states of nature. This central tendency was operationalized as the geometric intersection of the state distribution curves (the intersection was conditional upon the level of the distribution variable).

The results indicated that the expected point of central tendency was obtained for those subjects within the S1 distribution level, but that the expected point was statistically larger than that obtained for those subjects within the S2 distribution level. The state means were farther apart within the S2 distribution level than within the S1 level. As a consequence, the intersection of the state distribution curves was located farther from the standard (the mean of the in-control state) within the S2 distribution level than within the S1 level. An initial subjective bias provides a plausible explanation for the estimate obtained within the S2 level. This bias would take the form of a tendency to place greater weight on the standard as the intersection of the distribution curves became larger (i.e., shifted to a higher point on the actual minutes incurred axis).

An effect which differed from expectations was that the mean initial decision anchor given the C2 cost level was significantly larger than the mean initial decision anchor given the C1 level (equality was predicted). A bias of the estimates of the initial decision anchors may explain this difference. It will be recalled that the estimates had incorporated some initial adjustment (during the first training session). Those subjects within the C2 cost level were expected to adjust their initial decision anchors such that the value (actual minutes incurred) increased: those subjects within the C1 cost level were expected to adjust in the opposite direction. Initial adjustment in the appropriate directions would produce the obtained cost variable effect on the estimates of the initial decision anchors.

The second aspect of the anchoring and adjustment heuristic is the adjustment process. The adjustment process was examined using a measure of the individual's relative decision anchor adjustment. This observation variable, RA_i, was the linear distance over which the individual adjusted his decision anchor (the distance between his final decision anchor and the optimal decision value) relative to the linear distance over which the individual should have adjusted his decision anchor (the distance between his initial decision anchor and the optimal decision value). The results of analysis indicated that the RA_i measure did not differ significantly between the levels of the various situation variables. This was consistent with the predictions from the training phase simulation. A major limitation of the measure is that it is confined to the relative linear movement along the random variable decision axis. As such the RA_i measure is not sensitive to the learning of various situation parameters and variables (e.g., the

relative frequencies of the two states and the relative decision error costs), nor is it sensitive to the effects of various individual attributes (e.g., the individual's variable response range). Possible effects of the situation variables on these aspects of the adjustment process are examined in greater detail (with measures of greater sensitivity) in later sections relating to the individual decision criteria and the individual decision model sensitivity.

Individual Decision Model Sensitivity

Individual decision model sensitivity was measured employing a parameter of the TSD model, d'. This parameter measures the decision sensitivity of the individual's model relative to a theoretical sensitivity. The factors which can affect an individual's decision model sensitivity are 1) the use of a variable response range, and 2) the use of multiple decision anchors. To isolate these factors three decision sensitivity measures were developed: 1) the DN_i measure (which is affected by both factors), 2) the DNA_i measure (which is affected by only the variable response range), and 3) the DNA_i-DN_i measure (which is affected by only the multiple decision anchor).

The variable response range (the DNA_i measure) was affected primarily by the cost variable. That is, those subjects within the C2 cost level demonstrated larger variable response ranges than did those subjects within the C1 cost level. The locations of the optimal decision values and the subjects' final decision anchors were closer to the standard for the C1 cost level than for the C2 cost level (see Figure 2, Chapter III). The subjective adjustment limit concept offered

earlier may explain the difference in effect of the cost variable on the DNA_i measure. When the adjustment process involved convergence toward the standard the subjects may have perceived the standard as a limit to their adjustment process, a limit which they could have been reluctant to approach. When the adjustment process involved divergence from the standard the subjects did not have an objective value to perceive as a limit to their adjustment process. Whether a subject's adjustment process involved convergence toward or divergence from the standard depended upon the location of his initial decision anchor relative to the optimal decision value. This factor was conditional upon the cost variable. Given the C1 level the subject's initial decision anchor was greater than the optimal decision value and the adjustment process involved convergence toward the standard. Given the C2 level the opposite held: i.e., the subject's initial decision anchor was less than the optimal decision value and the adjustment process involved divergence from the standard. As subjects' adjustments within the C1 level converged toward the standard the subjective limit of the standard could have acted as an intervening variable which reduced the relative magnitude of the variable response range. As subjects' adjustments within the C2 cost level diverged from the standard no such subjective adjustment limit existed: therefore, the relative magnitude of the variable response range could have increased.

The higher (statistical) moments of the DNA_i measure given the levels of the cost variable were consistent with this concept of a subjective adjustment limit. Such a limit should have had the effect of reducing the variance of this measure. The test of the variances indicated that $(DNA_i|C1)$ had a significantly smaller variance than

($DNA_i|C2$). The subjective limit also should have had the effect of skewing the measure away from those values which indicated larger variable response ranges. The third moment (as expressed by the coefficient of skewness) of the DNA_i measure indicated that 1) the skewness of the ($DNA_i|C1$) distribution was positive (skewed away from values which indicated larger variable response ranges), and 2) the skewness of the ($DNA_i|C2$) distribution was negative (skewed toward values which indicated larger variable response ranges).

The multiple decision anchor variable (the DNA_i-DN_i measure) was affected primarily by the distribution variable. Those subjects within the S1 distribution level employed multiple decision anchors to a larger extent than did those subjects within the S2 level. The hypotheses posited a relation between multiple decision anchors and the distance separating the lower tail of the in-control state from the subject's final decision anchor. It was expected that the larger this distance (found within the C2 cost level and the S2 distribution level) the greater would have been the subject's propensity to have perceived a second out-of-control state below the existing in-control state (and used multiple decision anchors). However, the obtained results do not support this proposed relation.

The observed associations between the individual decision model sensitivity measures and intrinsic motivation have intuitive interpretations. The intrinsic motivation factor measured experimental task and experimental environment enjoyment as modified by decision performance satisfaction. As the subjects' use of multiple decision anchors and variable response ranges increased, their intrinsic motivation appeared to decrease. Since the use of multiple decision

anchors adversely affects decision performance (as reported by the feedback measure used in this research), their increased use would affect intrinsic motivation through the performance satisfaction modifier. Greater use of multiple decision anchors would result in poorer decision performance feedback measures: these measures, in turn, could lower the subject's decision performance satisfaction and thereby lower his intrinsic motivation. As the variable response range increases in relative size the number of decisions falling within this range increases. This requires more guesswork or more complicated decision rules on the part of the subjects, thereby increasing the difficulty (or the uncertainty) of the decision task. This increased task difficulty could affect the subject's enjoyment of the decision task and thus lower his intrinsic motivation.

Individual Decision Criteria

Individual decision criteria were measured using a parameter of the TSD model, β. This parameter measures the decision criteria used by the individual independent of his decision model sensitivity. The factors which can affect an individual's decision criteria are 1) the individual's efficiency in processing (or learning) the effects of the states' relative frequencies and the relative decision error costs, and 2) the use of multiple decision anchors. To isolate these factors several decision criteria measures were developed: 1) the BN_i measure (which is affected by both factors), 2) the BNA_i and BNC_i measures (which are affected by only the individual's information processing efficiency), and 3) the BNA_i-BN_i measure (which is affected by multiple decision anchors).

Those subjects within the C1 cost level produced significantly larger mean BNA_i measures than did those subjects within the C2 level. However, the BNA_i measure can not be interpreted strictly as a measure of the efficiency of individual information processing: rather, it is a function of such a measure, the BNC_i measure. This is due to characteristics of the data structure and the decision task. The β_i parameter is related monotonically to the random variable decision axis (actual minutes incurred). Consequently, for those subjects within the C1 cost level the β_i measure associated with the initial decision anchor is larger than the β_k measure, and the expected adjustment process has the effect of reducing the β_i measure. For those subjects within the C2 cost level the β_i measure associated with the initial decision anchor is smaller than the β_k measure, and the expected adjustment process has the effect of increasing the β_i measure. Therefore, where BNA_i is defined as the ratio of the final β_i measure and the β_k measure, a value greater than one is produced for those subjects within the C1 cost level and a value less than one is produced for those subjects within the C2 cost level. The BNC_i measure eliminates this systematic relation with the value of one.

The efficiency of information processing (learning) was affected primarily by the cost variable. Those subjects within the C1 cost level were significantly more conservative (less efficient) in processing the information than were those subjects within the C2 cost level. These results were the reverse of those predicted by the hypotheses. The subjective limit concept may again be introduced as an explanation. As subjects' adjustments within the C1 cost level converged toward the standard the subjective adjustment limit of the

standard could have acted as an intervening variable which increased the level of relative conservatism (reduced the level of relative information processing efficiency). As subjects' adjustments within the C2 cost level diverged from the standard no such subjective adjustment limit existed, thus the level of relative conservatism could have decreased.

The higher (statistical) moments of the BNC_i measure given the levels of the cost variable were consistent with this concept of a subjective adjustment limit. The difference in variances of the BNC_i measure was due to the difference in the ranges of the measure. The range of $(BNC_i|C1)$ was 4.67 and the range of $(BNC_i|C2)$ was 1.57. The subjective adjustment limit should have had the effect of skewing the measure away from those values which indicated lower levels of conservatism. The third moment (as expressed by the coefficient of skewness) of the BNC_i measure indicated that 1) the skewness of the $(BNC_i|C1)$ distribution was positive (skewed away from values which indicated lower levels of conservatism), and 2) the skewness of the $(BNC_i|C2)$ distribution was negative (skewed toward values which indicated lower levels of conservatism).

The multiple decision anchor (the BNA_i-BN_i measure) was affected primarily by the cost variable. Those subjects within the C1 cost level employed multiple decision anchors to a larger extent than did those subjects within the C2 cost level. The hypotheses posited a relation between multiple decision anchors and the distance separating the lower tail of the in-control state from the subject's final decision anchor. This relation was similar to that proposed in the DNA_i-DN_i measure. However, the results did not support the hypotheses

and thus parallel those obtained with the DNA_i-DN_i measure. Both the DNA_i-DN_i and the BNA_i-BN_i measures obtained results that indicated greater multiple decision anchor usage when the subjects' initial decision anchors were closer to the standard (the S1 distribution level within the DNA_i-DN_i measure and the C1 cost level within the BNA_i-BN_i measure). No plausible explanation for these results is readily apparent.

The obtained associations between the individual decision criteria measures and the individual attributes of extrinsic (monetary) motivation and subject GPA have intuitive interpretation. As both the extrinsic (monetary) motivation measures and the subjects' GPAs decreased the level of conservatism increased. Furthermore, as the subjects' GPAs decreased the use of multiple decision anchors increased. Of the two individual process variables (decision model sensitivity and decision criteria), the decision criteria had the more significant affect on a subject's performance feedback measure and, in turn, on the level of his monetary rewards. However, since motivation pre-tests were not administered,causal relationships (i.e., decreased motivation led to increased conservatism, or increased conservatism led to decreased motivation) can not be claimed.

Individual Long-Run Decision Efficiency

The overall efficiency of an individual's decision making within the experiment was measured using the G_i variable. The G_i variable was the individual's net additional decision costs relative to the optimal model's total decision costs. The G_i variable was disaggregated into two measures: the total additional individual decision costs relative

to the optimal model's total decision costs (GP_i) and the total additional individual decision savings relative to the optimal model's total decision costs (GN_i). The hypotheses concerning these variables were derived using a simulation which assumed a set of initial decision anchors and assumed equal learning efficiency (in terms of relative linear adjustments along the random variable axis). Given these assumptions, specific variations in the decision situation were expected to have specific effects on a subject's relative decision costs (see Table 4 in Chapter V for a summary of these expected effects and the obtained results). All of these expected decision situation effects were supported, at least in part, by the obtained results. However, the results of the individual decision model sensitivity and the individual decision criteria analyses indicated that learning efficiency was _not_ equal between the levels of the situation variables.

The support obtained for the hypotheses concerning decision efficiency variables would suggest that the unequal learning efficiency did not have a significant effect on the relative decision costs. The majority of the unequal learning efficiency occurred between the levels of the cost variable (the most significant effect, decision criteria conservatism, was greater within the C1 cost level than within the C2 level). A closer examination of both the simulated and the obtained cost variable effects on the G_i variable indicated that the obtained effects were not as strong as the simulated effects (note that $(\overline{G}_i|C2)/(\overline{G}_i|C1)$ equalled 1.61 whereas $f(\overline{G}_i|C2)/f(\overline{G}_i|C1)$ equalled 3.27). The simulated effects may be adjusted for unequal learning efficiency by assuming the relative decision costs within the C1 cost level would be increased by a factor of two (relative to the C2 cost level). After

this adjustment the simulated cost variable effects would have the same strength as the obtained effects (i.e., $f(\overline{G}_i|C2)/2 \cdot f(\overline{G}_i|C1)$ would equal 1.60).

The simulated and obtained distribution by cost variable interactions involving the relative decision costs had similar relationships between their strengths: the effects of the obtained interaction were not as strong as the effects of the simulated interaction (note that $[(\overline{G}_i|S1,C2)-(\overline{G}_i|S2,C2)] / [(\overline{G}_i|S1,C1)-(\overline{G}_i|S2,C1)]$ equalled 3.15 whereas $[f(\overline{G}_i|S1,C2)-f(\overline{G}_i|S2,C2)] / [f(\overline{G}_i|S1,C1)-f(\overline{G}_i|S2,C1)]$ equalled 8.74). Again, if the simulated effects are adjusted for unequal learning efficiency, then the simulated distribution by cost variable interactions have a strength similar to that of the obtained effects (i.e., $[f(\overline{G}_i|S1,C2)-f(\overline{G}_i|S2,C2)] / [2 \cdot f(\overline{G}_i|S1,C1)-2 \cdot f(\overline{G}_i|S2,C1)]$ would equal 4.37).

The simulated and obtained distribution by cost variable interaction within the GP_i/GN_i measure had opposite relationships between their strength: the effects of the obtained interaction were stronger than the effects of the simulated interaction (note that $[(\overline{GP_i/GN_i}|C2,S1)-(\overline{GP_i/GN_i}|C1,S1)] / [(\overline{GP_i/GN_i}|C2,S2)-(\overline{GP_i/GN_i}|C1,S2)]$ equalled 17.94 whereas $[f(\overline{GP_i/GN_i}|C2,S1)-f(\overline{GP_i/GN_i}|C1,S1)] / [f(\overline{GP_i/GN_i}|C2,S2)-f(\overline{GP_i/GN_i}|C1,S2)]$ equalled 3.82). To explain the difference in effect strengths requires reference to two variables: multiple decision anchors and unequal learning efficiency. If the GP_i/GN_i measures are adjusted for the effects of multiple decision anchors the strength of the obtained interaction effect is 2.89 (using the above interaction strength ratio). This reverses the relationships between the effect strengths: i.e., the obtained interaction strength becomes weaker

than the predicted strength. The effects of unequal learning efficiency were 1) an expansion of the interval between the final decision anchor and the optimal decision value for those subjects with greater decision criteria conservatism, and 2) the reduction of the interval between the final decision anchor and the optimal decision value for those subjects with less decision criteria conservatism. As the interval associated with those subjects within the C1 cost level expanded (this level had greater decision criteria conservatism), both the $(\overline{GP}_i|C1)$ and the $(\overline{GN}_i|C1)$ became larger. However, the $\overline{GP}_i$ measure became larger at a greater rate than did the $\overline{GN}_i$ measure $(\partial\overline{GP}_i/\partial\overline{GN}_i>1)$. As the interval associated with those subjects within the C2 cost level contracted (this level had less decision criteria conservatism), both the $(\overline{GP}_i|C2)$ and the $(\overline{GN}_i|C2)$ became smaller. However, the $\overline{GP}_i$ measure became smaller at a greater rate than did the $\overline{GN}_i$ measure $(\partial\overline{GP}_i/\partial\overline{GN}_i>1)$. Consequently, the ratio $(\overline{GP_i/GN_i}|C1)$ increased as the level of conservatism increased, and the ratio $(\overline{GP_i/GN_i}|C2)$ decreased as the level of conservatism decreased. Incorporating these effects of unequal learning efficiency into the simulated distribution by cost variable interaction lowered the predicted strength of such an interaction.

The observed associations between the individual long-run decision efficiency measures and the individual attributes may be interpreted with some degree of intuitive satisfaction. As the subjects' variable response ranges increased the relative decision costs increased (either as a result of increased additional decision costs or decreased additional decision savings). Furthermore, as the relative decision costs increased both the subjects' intrinsic and extrinsic (monetary) motivation measures decreased. A similar association existed between the

subjects' GPAs and the relative decision costs: as the subjects' GPAs increased either additional decision costs decreased or additional decision savings increased. It would be reasonable to assume that both the DN_i measure and the subject GPA are modifying variables on a subject's decision cost performance. Since pretests were not administered it was not possible to state the specific relations between the motivation factors and a subject's relative decision cost performance.

Limitations

The major limitations of this study involve two general aspects: the subjects employed within the experiment and the experimental environment itself. Although these aspects are discussed separately, in many instances the limitations they impose overlap one another. These limitations affect primarily the external validity of this study.

There are several possible limitations involving the experimental environment. First, the precision of subject performance feedback during the training phase could be a limitation. The results obtained in this study might be modified substantially if such accurate feedback was not employed. The lack of decision performance difference between the levels of the available information variable could be a direct result of this feedback: i.e., the accuracy of the performance feedback and its relationship with the optimal model may have replaced the need for such additional statistical information.

Second, the background of the subjects in relation to the experimental task is a possible limitation. Although the subjects received training in the experimental task, the primary source of their knowledge concerning standard cost variance investigation could come

from the college classroom. Consequently, if they were not taught (within the classroom) that situations exist in which investigation decision values are located relatively close to the standard, then greater decision criteria conservatism within these situations could be the result of the lack of such knowledge. This suggests the possibility of an availability bias (Tversky and Kahneman, 1973). However, to the extent a manager must learn from his own experiences, such a bias could exist in the real world.

A final limitation (discussed within this section) involves the selection of the levels of the situation variables. Several situation variables were set at a single level, while others were manipulated at multiple levels. The important point is that only specific combinations of variable levels were studied within this research whereas an infinite number of combinations are possible. Different variable levels and different variable manipulations would create a difference in the experimental environment which could produce results other than those obtained in this study.

These experimental environment limitations do not mean, however, that the concepts proposed within this study have not passed a meaningful empirical test. The objectives of experiments involving theory or concept testing, and the relations between the nature created in the experiment and the nature existing in the world at large are discussed by Zigler (1963):

> What the experimenter is saying is that if such and such holds in the real world because of the principles expounded in the particular theory under investigation, then such and such should hold in the world which the experimenter has created. This translatability is what gives theoretical import to experiments which involve phenomena which, taken in isolation, not only appear picayune but seem to have little relationship with what one observes in nature. (pp. 353-4).

Finding the proposed concepts to hold within the experimental world does not validate the claim that they hold within the real world. On the other hand, finding the proposed concepts not to hold within the experimental world would cast serious doubt on whether they hold in the real world. Positive experimental results are a form of negative assurance: the concepts have passed an initial empirical test and remain (albeit somewhat scarred in most instances) potential candidates for explaining real world phenomena.

The major limitation involving the subjects employed within this research is that they were college students, predominantly accounting majors. The obtained results and the conclusions based upon these results are not generalizable beyond some unspecified population of which the subjects are representative.

The selection of the type of subject to be employed within an experiment is not independent of the experimental environment. Within this research principal interest lies in the behavior of operational managers within real world environments. However, given the selection of the laboratory experimentation method (which implies the use of a surrogate experimental environment), the selection of the type of subject depends upon the answer to the question, "Which subject is a better surrogate for a manager in a real world environment, a knowledgeable student or the manager himself?" There are, of course, no clear answers to this question. However, several aspects of the situation favor the use of a knowledgeable student. First, the high degree of abstraction within the experimental environment could have made the task appear trivial to a manager and could have elicited behavior not consistent with the principal situation. Second, the

experimental environment is closer to that of a test-taking situation which is a more natural environment for a student than for a manager.

Implications For Accounting

Two general implications of this research for accounting are discussed. These implications are the value of additional information, and the general standard setting process.

Value of Additional Information

The manipulation of the information variable involved the quantity of information contained in the available information set, specifically the presence or absence of various distribution information items. The results indicated that the information variable did not have a significant effect upon the individual relative decision costs. The mean relative decision cost of subjects within the reduced information level did not differ significantly from that of subjects within the expanded information level. An implication of this result concerns the net benefit (for the company) of providing the additional information within the expanded information level. The additional information within an actual environment is not costless. Consequently, if such information is to be provided, other things being equal, the net benefit of such an action should be positive. In this context, the net benefit would be the marginal decision cost savings resulting from improved manager variance investigation decisions (given the additional information) less the costs associated with the production and dissemination of the additional information. Within this research the lack

of a significant information variable effect implies that the net benefit of providing additional information may not be positive. However, it should be noted that the lack of an information variable effect could be the result of either 1) that the subjects within the reduced information level were able to estimate (with relative efficiency) the missing information as a result of their experiences with the decision task, or 2) that the subjects within the expanded information level did not utilize the additional information efficiently.

General Standard Setting Process

Another implication of this research concerns the general standard setting process. Within decision situations involving either convergent or divergent adjustment decision criteria,conservatism was defined as a less than complete adjustment toward the optimal decision value. Convergent adjustment involved individual decision value adjustment toward the standard, and divergent adjustment involved individual decision value adjustment away from the standard. The standard used within this research can be conceived of as a type of decision behavior magnet. Over certain ranges of its field (the relevant decision axis) the standard attracts variance investigation behavior, and over other ranges of its field it repels variance investigation decision behavior. Decision criteria conservatism when the adjustment process diverges from the standard could be the result of the attraction (or pull) of the standard that restrains the individual from making a complete (divergent) adjustment to the optimal decision value. Decision criteria conservatism when the adjustment process converges to the standard could be the result of the repelling force

(or push) of the standard, subjectively limiting a complete (convergent) adjustment to the optimal decision value. The decision behavior magnet view represents a generalization of the subjective adjustment limit concept. The subjective limit concept as presented earlier dealt with decision criteria conservatism involving only convergent adjustment.

The question of whether decision makers could learn (either through training or experience) to reduce the decision biases implied by the decision behavior magnet concept remains unanswered. An alternative approach, however, involves the standard setting process itself. Previous research involving the nature of standards (e.g., strict standards, currently attainable standards, lax standards) has primarily dealt with the standard's motivational affects. Other things being equal, the nature of the standard may affect the decision behavior magnet biases. Within situations requiring adjustment, lax standards (which have values greater than the mean of the in-control state) may reduce substantially divergent decision criteria conservatism. Within situations requiring convergent adjustment, strict standards (which have values less than the mean of the in-control state) may reduce substantially convergent decision criteria conservatism.

Future Research

The implications of this study for future accounting research take two general forms: modification of the existing conceptual development and generalizations of the modified conceptual development. Modifications of the existing conceptual development would involve incorporating and testing the ex post explanations offered for certain

variance investigation decision behavior observed within this research. Generalization of the modified conceptual development would involve extensions aimed at reducing the limitations of the existing study.

The primary ex post concept developed within this research is the decision behavior magnet view (incorporating the concept of subjective limits). Future research could directly test this concept. Such research could involve variance investigation decision situations in which the standard was not the same value as the mean of the in-control state of nature. If this ex post concept is valid, then subjects within situations involving convergent adjustment and a strict standard should have less decision criteria conservatism than subjects within situations involving convergent adjustment and a lax standard. Similarly, subjects within situations involving divergent adjustment and a lax standard should have less decision criteria conservatism than subjects within situations involving divergent adjustment and a strict standard. Additional research could test whether the biases implied by the decision behavior magnet concept can be reduced or eliminated by extended training within the particular decision situation.

Generalizations of the conceptual development would require extensions concerning both the experimental subjects and the experimental environment. Extensions concerning the experimental subjects could involve the use of non-students, perferably actual operational managers. Such extensions could include managers within familiar experimental environments and within non-familiar experimental environments. Beyond extending the decision criteria conservatism effects, the central question would be whether differential information processing

efficiency (decision criteria conservatism) is a characteristic of only training (learning) situations or remains a characteristic of well-trained (non-learning) situations.

Extensions involving the experimental environment could take several forms. First, they may relate to the levels of the situation variables. Only certain situation variables were studied within this research: extensions could study the affects of manipulating different situation variables at different levels (e.g., more than two states of nature, non-normal distributions, variable relative frequencies, variable decision cost functions, multiple standard cost variances).

Second, extensions could be made in relation to the experimental task itself. Within this research the decision task was of a cross-sectional nature: i.e., each decision trial was independent of the previous decision trials. An extension could involve a decision task of a time-series nature: i.e., where each decision trial would be dependent on the previous decision trials. Such a decision task extension would involve sequential decision making, where the physical process is initially in some state of nature and over a series of decision trials (variance reports) the process may or may not move to another state of nature. The task of the decision maker would be to detect the point in time in which the physical process shifts to another state.

The third and final extension discussed within this section concerns the nature of the experimental decisions. Within this research the decisions involved the detection of state of nature for the purpose of physical process control within cost minimization constraints. Beyond the operational control level, standard variance reports can be

utilized as performance measures for the appropriate operational managers and for the physical systems under their control. The nature of decisions of this type, although generally aggregated over longer time periods, is that of adequate performance verses inadequate performance rather than that of investigation verses non-investigation. Within the current research, performance decisions were assumed implicitly within the performance feedback measures given the subjects during the training phase. An extension would involve the actual formation of such decisions and, in turn, their effects upon operational control decisions.

APPENDIX A

THEORY OF SIGNAL DETECTION DERIVATIONS

Relationship of Conditional Probability Matrix and Bayes' Theorem

The unconditional probabilities of the four event outcomes can be stated in terms of the conditional probabilities and the prior probabilities of the sn and n distributions: 1) the probability of a hit, $P(sn,Y)$ equals $P(Y|sn)P(sn)$; 2) the probability of a miss, $P(sn,N)$ equals $P(N|sn)P(sn)$; 3) the probability of a false alarm, $P(n,Y)$ equals $P(Y|n)P(n)$; and 4) the probability of a correct rejection, $P(n,N)$ equals $P(N|n)P(n)$.

Egan (1975, pp. 12-13) demonstrates the relationship between the single-interval procedure and Bayes' theorem. The posterior probability of the event sn, given the discrete observation x, can be represented as $P(sn|x)$. Since the two events sn and n are exhaustive the addition of $P(sn|x)$ and $P(n|x)$ equals one. The posterior probability of the event sn can be stated as $P(sn,x)$ which equals:

$$P(x|sn)P(sn) = P(sn|x)P(x).$$

Rearranging the terms of this equality and expanding the $P(x)$:

$$P(sn|x)= \frac{P(x|sn)P(sn)}{P(x|sn)P(sn) + P(x|n)P(n)}$$

This equation is a simple expression of Bayes' theorem. It can be extended to the odds form, the posterior odds equals the prior odds times the likelihood ratio of the observation x:

$$\frac{P(sn|x)}{P(n|x)} = \frac{P(sn)}{P(n)} \cdot \frac{P(x|sn)}{P(x|n)}$$

Egan (1975) further demonstrates that the posterior probability is strictly monotone with the likelihood ratio of x, $L(x)$; that is, when $L(x_2) > L(x_1)$ then $P(sn|x_2) > P(sn|x_1)$.

Maximization of Expected Value Objective Function

The decision function for maximizing the expected value decision goal is:

$$E(V) = P(Y|sn)P(sn)V_{sn,Y} + P(Y|n)P(n)V_{n,Y}$$
$$+ P(N|n)P(n)V_{n,N} + P(N|sn)P(sn)V_{sn,N}$$

Given an observation x, the subject has two decision functions:

1) $E(V|x,Y)$, the expected value given the observation and the subject responds "Yes," and
2) $E(V|x,N)$, the expected value give the observation and the subject responds "No."

These two decision functions can be expressed as the sum of the values associated with each decision weighted by the appropriate posterior probability:

$$E(V|x,Y) = P(sn|x)V_{sn,Y} + P(n|x)V_{n,Y}, \text{ and}$$
$$E(V|x,N) = P(n|x)V_{n,N} + P(sn|x)V_{sn,N}.$$

The subject should say "Yes" only if $E(V|x,Y) > E(V|x,N)$. If the righthand side of the above two equations are used in this inequality, then the subject should say "Yes" only when:

$$P(sn|x)V_{sn,Y} + P(n|x)V_{n,Y} > P(n|x)V_{n,N} + P(sn|x)V_{sn,N}$$

Rearranging the terms and expressing the posterior odds in terms of the prior odds and the likelihood ratio of x results in the decision rule for saying "Yes" in terms of the likelihood ratio of the observation:

$$\frac{P(x|sn)}{P(x\ n)} > \frac{P(n)}{P(sn)} \cdot \frac{V_{n,N} - V_{n,Y}}{V_{sn,Y} - V_{sn,N}}$$

APPENDIX B

ORAL PRESENTATION TO ELICITE VOLUNTEER SUBJECTS

I assume that most, if not all, of you intend to become accountants. You should realize that accounting is more than an occupation, it is a profession. As a member of a profession you have certain responsibilities beyond those encountered in other occupations. One of these responsibilities is the readiness to help expand the state of the art, the level of knowledge, of the profession. Today you have an opportunity to meet this responsibility. As part of my Ph.D. requirements I am conducting an experiment which examines the impact upon decision makers of certain accounting produced information. I am asking that you volunteer to participate as subjects in this experiment.

The accounting information under study is the standard cost variance report and, as a subject, you would be asked to assume the role of an operations manager and to make certain decisions based upon standard cost variance reports. After volunteering, greater detail concerning the role and the required decisions will be provided in a short booklet and in a training session.

Benefits to volunteering as a subject, beyond meeting part of your professional responsibilities, include:

1) A chance to expand your knowledge of standard cost variance reports and their utilization from the point of view of a line manager.

2) A chance to earn up to $10.00 as payment for participating in the experiment.

3) A chance to gain first-hand experience with an accounting research project.

Your participation in the experiment would not involve a great sacrifice of your time. The entire experiment requires only two one-period sessions. The times of these sessions are flexible to meet the requirements of your personal schedule. The first one-period session, a training session, would be scheduled sometime on Monday or Tuesday, April 10th and 11th. The second one-period session, the actual experiment, would be scheduled sometime on Wednesday or Thursday, April 12th and 13th.

I can assure you that your responses within the experiment will be held strictly confidential. Only aggregate or anomymous results will be made public.

I will pass around a sign-up sheet; I would appreciate it if everyone would print their name and indicate with a check-mark whether you are willing to participate. If you are willing to participate, fill in your phone number and indicate some times that I can contact you to schedule your participation.

I would like to thank you in advance for your time. The overall success of this study is dependent upon a positive response from most of you in this room. I am confident that as professionals you will exceed my expectations.

Does anyone have any general questions?

APPENDIX C

BACKGROUND INFORMATION BOOKLET

The following represents background information concerning the role that you will be asked to assume in the business experiment for which you have volunteered to participate. Please read this information several times, familarizing yourself with the general aspects of this role.

More detailed information together with specific instructions will be presented at the inception of the actual experiment. You may use this booklet when you participate in the experiment.

PLEASE DO NOT DISCUSS THIS EXPERIMENT WITH OTHER PEOPLE. If you have questions contact Clif Brown (Bryan 214E or telephone 2-0155).

My Training Session is:

Date:_______________ Time:_______________ Room:_______________

My Experiment Session is:

Date:_______________ Time:_______________ Room:_______________

You will be asked to assume the role of an assembly department operational control manager and within this role you will be asked to make certain decisions based upon information that will be presented to you. The specific nature of these decisions will become clear as you read this background information booklet.

General Company Information

Assume you are employed by the American Seating Company (AMSECO). AMSECO manufactures and sells public seating and institutional furniture to education, amusement, transportation and health care markets. The company is one of the largest suppliers in each of its markets. Selected AMSECO financial statement items for the previous calendar year include:

Net Sales	$ 84,000,000
Cost of Sales	$ 67,250,000
Net Income	$ 1,550,000
Total Assets	$ 60,465,000
Net Assets	$ 33,947,000

General Product Information

The assembly department of which you are the operational control manager is engaged in the manufacturing of a metal folding chair. Since the major market for the folding chair is the education market the chair must meet stricter specifications than the typical home-use variety. The chair is produced in three styles, the only difference between the styles is the color; grey, brown, and black. The production of the folding chair averages 1,000 chairs per week; this production accounts for approximately 1.5 percent of AMSECO's net sales.

Metal Folding Chair Manufacturing Process

The folding chair is manufactured within three operational departments using a sequential production system. The three departments are fabrication, finishing, and assembly; you are the operational control manager of the metal folding chair assembly department.

The fabrication department manufactures the parts required to make the folding chair and transfers them to the finishing department in large identical unit batches. The finishing department paints and finishes the metal parts and groups them into kits, each kit containing the parts necessary to assemble one folding chair. The kits are transfered to the assembly department in 200 kit batches. The assembly department assembles the folding chair kits in 200 chair job-orders, packages each assembled chair, and transfers them to the product inventory department.

Metal Folding Chair Assembly Department

Employees

The assembly department employs one operational control manager (yourself), one assembly supervisor, fifteen full-time assembly workers, and two packagers. Two quality control inspectors work within the

assembly department; however, the costs associated with the inspectors are not charged directly to the assembly department but rather to a central product engineering and quality control department.

The assembly supervisor does not actually participate in the physical assembly procedures but rather supervises the assembly workers, the kit input to the assembly department, the packagers, and the finished chair output to the product inventory department.

The operational control manager (yourself) has overall responsibility for assembly department product scheduling, physical assembly process and procedures, and operational efficiency.

Physical Process

Five years ago the folding chair assembly was accomplished using an assembly-line type process in which each assembly worker performed a specific, repetitive task. An experiment at that time, however, demonstrated that greater worker efficiency could be obtained if each worker was responsible for the complete assembly of a chair. The result was that the average time required to assemble a chair decreased substantially. Consequently, the current assembly process consists of each assembly worker assembling a complete chair from a kit. The single largest drawback of this method is that the assembly line goes out-of-control much more often than when the previous assembly method was utilized. It is believed, however, that the net benefits of the current method outweights this drawback.

The folding chair assembly is accomplished following a predetermined assembly sequence. After assembling a folding chair the worker places it on a conveyor belt which takes it to the quality control inspectors. The onsight quality control process consists of a visual inspection of the chair's finish and a manual inspection of the chair's operation. A chair which passes this inspection is folded and placed on a conveyor belt which takes it to the packagers. A chair which does not pass this inspection is placed in a rework area with a form indicating the reason for inspection failure. Periodically the central quality control department randomly selects a sample of finished chairs and performs additional structural tests. The packagers box each folded chair in a corregated cardboard carton, stamping the carton with the color of the chair.

Accounting Control System

AMSECO utilizes a job-order costing and control system employing standard costs. The folding chair is manufactured and controlled in 200 chair lots. The assembly department is charged only with material usage and labor efficiency variances, not with material price and wage rate variances. In the past the material usage variance has been negligable and the operating performance of the assembly department has been completely determined by the labor efficiency of the workers.

Engineering estimates and historical statistical studies have been used to set the labor efficiency standards within the assembly department. These labor efficiency standards are reasonably attainable and allow for unavoidable labor inefficiencies and reasonable variation in worker performance. As the operational control manager you should accept the labor efficiency standards in terms of fair control and performance goals.

The per chair labor efficiency standards for the assembly department are:

Process	Standard Time Allowed
Assembly	33 minutes
Packaging	3 minutes
Total	36 minutes

The variance report contains only the labor efficiency variance and this variance is reported only in aggregate form (i.e., the variance is not broken into the assembly and packaging processes). The accounting system is computerized and the variance report is in computer output format.

The physical labor process of the assembly department can be in one of two states; either in-control or out-of-control. The overall labor process is made up of many individual physical labor procedures; the expected aggregate of these procedures is represented by the labor efficiency standard of 36 minutes per chair. The department is defined to be in-control when all of these physical procedures are performed as expected. The department is defined to be out-of-control when one or more of these physical labor procedures are not performed as expected. Since the overall labor process is made up of many individual labor procedures it is possible for the department to be out-of-control while at the same time the reported labor efficiency variance is small. This would occur when some of the individual procedures are performed at higher than normal efficiency while other procedures are performed at subnormal (out-of-control) efficiency. It is also possible for the department to be in-control while at the same time the reported labor efficiency variance is large. This would occur when most of the indivdual procedures are performed at slightly below normal efficiency. These examples represent two extreme situations; the probability of occurance for either of them is low when compared to the probabilities of occurance for situations that fall inbetween the two extreme examples.

Your Task as the Operational Control Manager

Based upon the variance report you must decide whether to investigate the particular labor efficiency variance for its underlying causes. The purpose of investigation is to facilitate correcting those indivdual labor procedures which are not operating as expected. The following assumptions will aid your decision making:

1) If you decide to investigate the variance and the assembly department turns out to be out-of-control, the department will be returned to the original in-control state with certainty.
2) If you decide not to investigate the variance and the assembly department turns out to be out-of-control, the department will remain out-of-control with certainty.

There are certain marginal costs associated with the variance investigation decision. These costs depend upon your decision (either investigate or do not investigate) and upon the actual state of the assembly department (either in-control or out-of-control). These marginal costs have the following values and relationships:

If Your Investigation Decision Is	And If The Assembly Line State Is	Then Your Costs Are Investigation	Production	Total
Investigate	In-control	\$ X	\$ 0.00	\$ X
Investigate	Out-of-control	\$ Y	\$ 0.00	\$ Y
Not Investigate	In-control	\$ 0.00	\$ 0.00	\$ 0.00
Not Investigate	Out-of-control	\$ 0.00	\$ 175.00	\$ 175.00

X represents the variable investigation cost when the assembly line is in-control. This investigation cost is related to the size of the labor efficiency variance; the more negative (unfavorable) the variance the larger this cost.

Y represents the variable investigation cost when the assembly line is out-of-control. This investigation cost also is related to the size of the labor efficiency variance; the more negative (unfavorable) the variance the smaller this cost. For any given labor efficiency variance the investigation cost if the assembly line is out-of-control, Y, is always larger than the investigation cost if the assembly line is in-control, X. This is due to the investigation cost including the cost of correcting the out-of-control labor procedure when the assembly line is out-of-control.

The \$175.00 cost is the expected marginal production cost of operating next period in the out-of-control state. This cost is fixed for all labor efficiency variance reports.

Your Performance Measure as the Operational Control Manager

The metal folding chair section manager (your immediate supervisor) evaluates your control performance in terms of the minimization of both investigation costs and production costs above the expected standard (the total of these costs is called the Total Investigation Decisions Cost). The extent to which your investigation decisions for a specified period of time minimizes the Total Investigation Decision Cost is determined as follows:

$$\text{Extent of Total Investigation Decisions Cost Minimization} = \frac{\text{Total Investigation Decisions Cost of your decisions}}{\text{Optimal Total Investigation Decisions Cost}}$$

The optimal Total Investigation Decisions Cost is determined by the section manager at the end of the specified period of time. It is possible for your Total Investigation Decisions Cost to equal the optimal Total Investigation Decisions Cost. AMSECO pays a cash bonus based on this measure of the extent of Total Investigation Decisions Cost minimization. The closer this measure is to one or less than one the larger the cash bonus.

The cash bonus for 100 labor efficiency variance reports is as follows:

Extent of Total Investigation Decisions Cost Minimization	Cash Bonus
1.000	\$ 10.00
1.001 to 1.010	9.00
1.011 to 1.020	8.00

Extent of Total Investigation Decisions Cost Minimization	Cash Bonus
1.021 to 1.030	$ 7.00
1.031 to 1.040	6.00
1.041 to 1.050	5.00
1.051 to 1.100	4.00
1.011 to 1.150	3.00
1.151	2.00

Again, I rely on your not discussing this experiment with other people.

APPENDIX D
PRIOR INFORMATION SHEETS

Experiment Condition (I1,S2,C2)

The following information is based upon past experience and past observations of the assembly line. This information may be helpful to you in making your decisions.

The portion of time the assembly line was:

In-control	60%	Out-of-control	40%

The actual minutes per chair for both states are assumed to be normally distributed.

The most favorable labor efficiency variance was:

10.0 minutes per chair (26.0 actual minutes incurred per chair)

The most unfavorable labor efficiency variance was:

19.0 minutes per chair (55.0 actual minutes incurred per chair)

The maximum investigation cost when the assembly line state was:

In-control	$ 98.75	Out-of-control	$ 154.17

The minimum investigation cost when the assembly line state was:

In-control	$ 62.50	Out-of-contro	$ 142.08

Experiment Condition (I2,S2,C2)

The following information is based upon past experience and past observations of the assembly line. This information may be helpful to you in making your decisions.

The two assembly line state means, in minutes per chair, are:

In-control	36.0	Out-of-control	45.0

The two assembly line state standard deviations, in minutes per chair:

In-contorl	5.0	Out-of-control	5.0

The portion of time the assembly line was:

In-control	60%	Out-of-control	40%

The actual minutes per chair for both states are normally distributed.

The most favorable labor efficiency variance was:

10.0 minutes per chair (26.0 actual minutes incurred per chair)

The most unfavorable labor efficiency variance was:

19.0 minutes per chair (55.0 actual minutes incurred per chair)

The maximum investigation cost when the assembly line state was:

In-control	\$ 98.75	Out-of-control	\$ 154.17

The minimum investigation cost when the assembly line state was:

In-control	\$ 62.50	Out-of-control	\$ 142.08

APPENDIX E

SUBJECT HEURISTIC ELICITATION QUESTIONNAIRE

Please answer the following questions in the spaces provided. This is not a test; there are no right or wrong answers. It is important that you try to answer each question honestly. If you need additional space use the back of this questionnaire.

1. What rule or set of rules did you use to make your investigation decisions in the last 50 labor efficiency variance reports (the second block)? Please include any numerical values that were part of this rule or set of rules.

2. Do you feel you used the same rule or set of rules as you gave in question one to make your variance investigation decisions in the first 50 labor efficiency variance reports (the first block)? If not the same, how does the rule or set of rules used in the first 50 reports differ from what you gave in question one? Please include any numerical values used as part of the rules or sets of rules that were different.

3. Rate the following items of information in terms of their importance to you in making your variance investigation decisions (do not rate the 'other' item unless you have specified some other information). Circle the appropriate response.

   A. The background information booklet.

Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

   B. The information based upon past experience and past observation which was presented in the front of each experiment booklet.

Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

   C. The standard minutes allowed per chair.

Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

D. The actual minutes incurred per chair.

**********	**********	**********	**********	**********
*	*	*	*	*
Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

E. The labor efficiency variance per chair.

**********	**********	**********	**********	**********
*	*	*	*	*
Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

F. The total chairs produced.

**********	**********	**********	**********	**********
*	*	*	*	*
Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

G. The costs associated with investigation decisions.

**********	**********	**********	**********	**********
*	*	*	*	*
Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

H. Other (please specify)______________________________.

**********	**********	**********	**********	**********
*	*	*	*	*
Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important

4. Recalling the training phase which you completed at an earlier time, what rule or set of rules did you use to make your variance investigation decisions in the <u>first 33</u> variance reports? Please include any numerical values that were part of this rule or set of rules.

5. How did you initially form the rule or set of rules you gave in question four? What lead you to use this particular rule or set of rules?

6. If the rule or set of rules you gave in question four is different from the rule or set of rules you gave in question one, what caused you to make the change?

7. What other information items, if presented, do you feel would improve you variance investigation decisions?

8. Were your decisions influenced by discussions with other participants in this experiment?

APPENDIX F

SUBJECT MOTIVATION QUESTIONNAIRE

Please respond to the following questions by circling the appropriate response. This is not a test; there are no right or wrong answers. It is important that you try to answer each question honestly.

1. Suppose this same experiment was to be repeated on a number of future occasions. How many more times would you be prepared to participate in the experiment under circumstances similar to the present?

****

*	*	*	*	*	*	*
No More Times	1 More Time	2 More Times	3 More Times	4 More Times	5 More Times	More Than 5 Times

2. Did your desire to perform well in undertaking a challenging task cause you to try very hard?

****

*	*	*	*	*	*	*
Definitely Yes	Yes	Probably Yes	Don't Know	Probably No	No	Definitely No

3. Did you enjoy making the decisions required in the experiment?

****

*	*	*	*	*	*	*
Definitely No	No	Probably No	Don't Know	Probably Yes	Yes	Definitely Yes

4. Are you satisfied with your performance in the experiment?

****

*	*	*	*	*	*	*
Definitely Yes	Yes	Probably Yes	Don't Know	Probably No	No	Definitely No

5. Do you think you would have tried less hard if the money rewards had been halved?

****

*	*	*	*	*	*	*
Definitely No	No	Probably No	Don't Know	Probably Yes	Yes	Definitely Yes

6. Did you feel tense during the experiment?

*	*	*	*	*	*	*
Definitely Yes	Yes	Probably Yes	Don't Know	Probably No	No	Definitely No

7. Did your desire to cooperate with the experimenter cause you to try very hard?

*	*	*	*	*	*	*
Definitely No	No	Probably No	Don't Know	Probably Yes	Yes	Definitely Yes

8. Do you think the money rewards caused you to try harder than you would have without them?

*	*	*	*	*	*	*
Definitely Yes	Yes	Probably Yes	Don't Know	Probably No	No	Definitely No

9. Did you enjoy the overall experience of participating in the experiment?

*	*	*	*	*	*	*
Definitely No	No	Probably No	Don't Know	Probably Yes	Yes	Definitely Yes

10. Did your desire to contribute to research knowledge cause you to try very hard?

*	*	*	*	*	*	*
Definitely Yes	Yes	Probably Yes	Don't Know	Probably No	No	Definitely No

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BIOGRAPHICAL SKETCH

Clifton Edward Brown was born on May 17, 1947,in Kansas City, Kansas. In June 1965 he graduated from St. Petersburg High School, St. Petersburg, Florida. Mr. Brown enlisted in the United States Air Force from 1965 through 1968, and was honorably separated with the rank of Sergeant. He was married in December 1968 to Sandra Cornell.

Mr. Brown attended the University of South Florida from which he graduated in June 1971 with a Bachelor of Arts degree majoring in accounting. From graduation until 1974 Mr. Brown was employed as an industrial accountant, during which time he held positions of controller and vice-president of finance. From September 1974 until the present Mr. Brown has attended the University of Florida where he has studied for a Doctor of Philosophy degree in business administration (accounting).

While attending the University of Florida, Mr. Brown was the recipent of the Price Waterhouse Foundation Grant, the American Accounting Association Fellowship Grant, and the Haskin and Sells Fellowship Grant. Mr. Brown was elected by the faculty as the university representative to the 1976 American Accounting Association Doctoral Consortium.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Professor of Accounting

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gary L. Holstrum
Associate Professor of Accounting

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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